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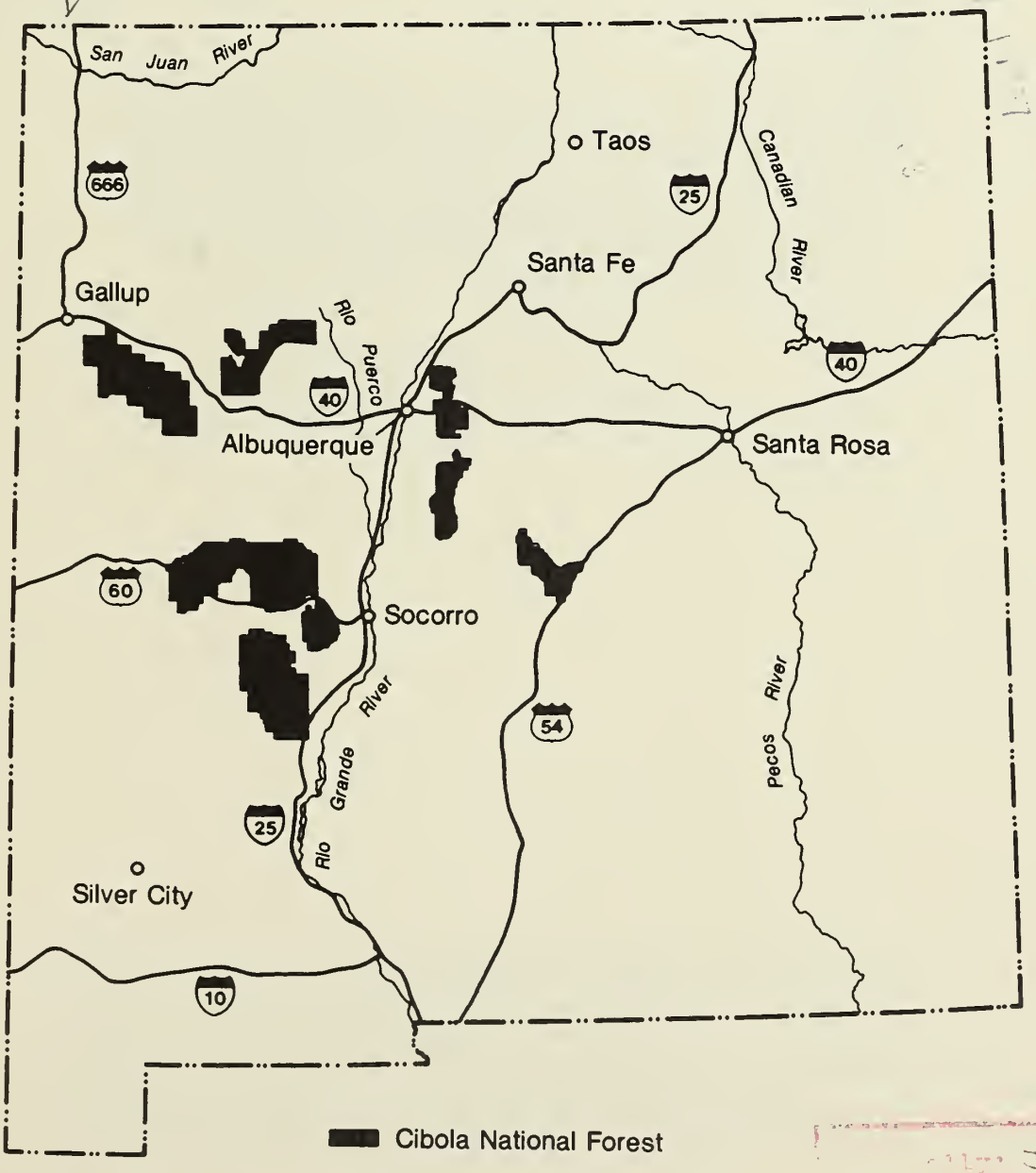
**General Technical
Report RM-143**

A Classification of Forest Habitat Types of the Northern Portion of the Cibola National Forest, New Mexico

**Billy G. Alexander, Jr.,
E. Lee Fitzhugh,
Frank Ronco, Jr.,
and,
John A. Ludwig**

[1987]



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Abstract

Vegetational data were collected from 124 sample plots on the Cibola National Forest, New Mexico, to develop a forest habitat classification based on potential natural vegetation. The 21 habitat types identified represent six climax forest series: *Picea engelmannii*, *Abies lasiocarpa*, *Picea pungens*, *Abies concolor*, *Pseudotsuga menziesii*, and *Pinus ponderosa*. A habitat type key is included for field identification. Each habitat type is described by vegetational composition, topographical occurrence, and related and adjacent habitats.

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A Classification of Forest Habitat Types of the Northern Portion of the Cibola National Forest, New Mexico[1]

Billy G. Alexander, Jr., Science Instructor
Weston-McEwen High School, Athena, Oregon[2]

E. Lee Fitzhugh, Extension Wildlife Specialist
University of California, Davis[3]

Frank Ronco, Jr., Principal Silviculturist
Rocky Mountain Forest and Range Experiment Station

John A. Ludwig, Professor
New Mexico State University[4]

[1]*This work was performed under contract with the Rocky Mountain Forest and Range Experiment Station, with headquarters in Fort Collins, Colo., in cooperation with Colorado State University. Supervision was provided by the Station's Research Work Unit at Flagstaff, Ariz., in cooperation with Northern Arizona University.*

[2]*Field work and manuscript preparation were conducted while the author was research assistant at Northern Arizona University and post-graduate researcher at the University of California, respectively.*

[3]*Work began while the author was Assistant Professor, Northern Arizona University.*

[4]*Current title and address: Senior Research Scientist, Commonwealth Scientific and Industrial Research Organization, Deniliquin, New South Wales, Australia.*

Contents

A Classification of Forest Habitat Types of the Northern Portion of the Cibola National Forest, New Mexico

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INTRODUCTION

The forests of the Cibola National Forest cover extensive areas with diverse vegetation. Classifying and defining vegetational units within the diverse forest ecosystem is important to forest resource management planning and its application. A classification is a basis for communication among land managers about vegetational responses to ecological changes.

Many previous studies of vegetational composition in the southwestern United States have been descriptive, but have not been comprehensive (Merkle 1954, Moir 1967, Hanks and Dick-Peddie 1974, Dye and Moir 1977). Other studies concentrated on classification systems with limited application because they described only broad vegetational units (Donart et al. 1978, Layser and Schubert 1979).

Moir and Ludwig (1979) took the first step towards a regional forest habitat type classification. Their study classified the mixed conifer and spruce-fir forests of Arizona and New Mexico and provided a guide for further studies of other forest series. Hanks et al. (1983) classified forest habitat types for the *Pinus ponderosa* series in Arizona. Alexander et al. (1984b) expanded the classification for the *Pseudotsuga menziesii* series in Arizona. Other studies classified the following National Forests: Lincoln (Alexander et al. 1984a); Apache, Cibola (Magdalena District only), and Gila[5]; Carson, Santa Fe, San Juan, and parts of the Rio Grande and San Isabel (DeVelice et al. 1986). Field work also is in progress to develop classifications for the Coronado, Prescott, and Tonto National Forests in Arizona.[6]

The terminology used in this paper follows Daubenmire (1968). A plant association is the plant community representing potential natural vegetation, which is the climax vegetation on a site resulting from natural succession. All areas that are capable of supporting the same plant association are termed a habitat type (HT), and a phase (P) is a classification level that retains overstory and undergrowth characteristics of habitat types, but differs uniformly and predictably in minor vegetational and site components.

Climax vegetation is the assemblage of plant abundance and composition in equilibrium with the environment in the absence of disturbance. An edaphic climax can occur where soil types and conditions are the primary influences on vegetation composition, and topographic climaxes occur where topography is the primary influence. Where topography also affects soil development, the combined effect results in a topo-edaphic climax. The vegetation of climax sites where soils and topography are of a secondary influence are called climatic climax, where climate is the primary influence.

Recurring disturbances can create shifts in plant equilibriums resulting in changes in abundance and composition, and the establishment of disclimax vegetation. A common disclimax, with specific species composition, is maintained by repetitive fire.

STUDY AREA

The Cibola National Forest is in north-central New Mexico (fig. 1). The administrative units covered by this study include the Mount Taylor, Sandia, and Mountainair Ranger Districts. However, no plots suitable for developing a classification were found in the Gallinas Mountains of the Mountainair District. The Magdalena Ranger District, at the southern end of the Forest, was not sampled because it was included in a previous study involving the Gila and Apache National Forests[5]. The Ranger Districts are not contiguous; the study area is fragmented into several mountain ranges, including the San Mateo Mountains, Zuni Mountains, Sandia Mountains, and Manzano Mountains (fig. 2).

The San Mateo Mountains referred to in this study are those northeast of Grants, New Mexico, and include Mount Taylor which, rising to over 11,000 feet (3,350 m), is the highest peak. Another range, also known as the San Mateo Mountains, is on the Magdalena District. The Zuni Mountains, west and southwest of Grants, are lower, reaching just over 9,200 feet (2,800 m). The Oso Ridge of the Zuni Mountains form the Continental Divide in this area. The Sandia Mountains, east of Albuquerque, form the abrupt Sandia Crest, which is a large west-facing escarpment rising to over 10,500 feet (3,200 m). The Manzano Mountains are southeast of Albuquerque, with elevations over 9,300 feet (2,835 m).

The Mount Taylor region encompasses the largest volcanic field in the study area; parent materials are primarily basaltic. This field consists of a series of mesas, including Horace Mesa, Jara Mesa, and Mateo Mesa. The southeast portion of the Zuni Mountains is also the site of a volcanic field where cinder soils are prevalent. Flows of old malapais or lava also are found in this region. The

[5] *Fitzhugh, E. Lee, William H. Moir, John A. Ludwig, and Frank Ronco, Jr. Forest habitat types in the Apache, Gila, and part of the Cibola National Forests. Manuscript in preparation. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.*

[6] *Forest habitat type classification on these Forests is now being conducted under cooperative agreement with New Mexico State University, with supervision provided by the Rocky Mountain Station's Research Work Unit in Flagstaff, Ariz.*

remainder of the Zuni Mountains has been uplifted by granitic rocks extruded through strata of limestones, siltstones, sandstones, and shales (Williams 1967). The Sandia Crest and the Manzano Mountains also are uplifts. The overlying limestones and siltstones have remained intact, resulting in less granitic and gneissic parent materials.

The climate of the Cibola National Forest is continental, with two wet and two relatively dry periods. During the winter (December through March), precipitation is mostly snow resulting from large Pacific Coast frontal storms. During the summer (July through September), large convectional thunderstorms account for the precipitation, with moisture derived from air masses originating in the Gulf of Mexico. The spring and fall months are relatively dry. In the Mount Taylor Ranger District, 22–33% of the annual rainfall is in the winter; 41–50% is in the summer (Williams 1967). Precipitation patterns are similar for the Sandia and Mountainair Ranger Districts (Bourlier et al. 1970). Temperature for this region varies widely, both seasonally and daily; daily variation in winter may be as much as 75° F (24° C).

Throughout the Southwest, mountain ranges are isolated, with desert or grassland intervening, and are characterized as biogeographical islands. Much of the diversity in plant communities is a result of the wide differences in topography in the area. The monocline forming the Oso Ridge of the Zuni Mountains results in cool, moist canyons along its southwestern slope. The topographical relief of Mount Taylor supports several different plant communities, including the spruce-fir forests

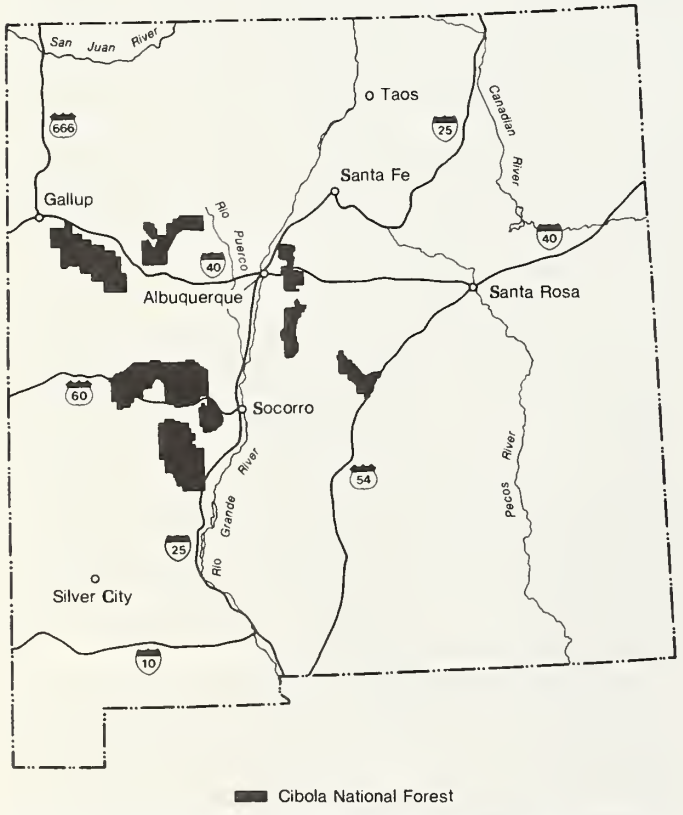

Figure 1.—Location of the Cibola National Forest in the state of New Mexico.

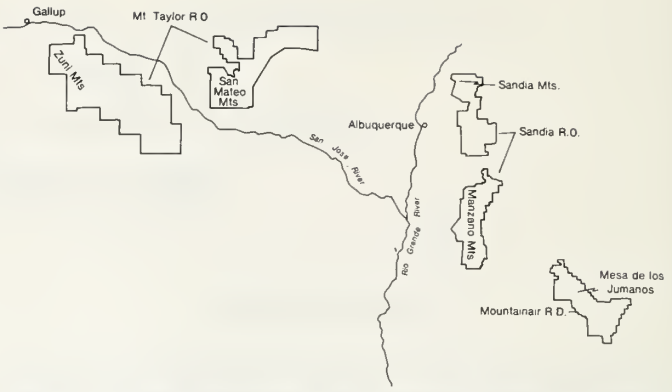

Figure 2.—Ranger Districts and major mountain ranges covered by the study. The Magdalena Ranger District of the Cibola National Forest was classified in earlier work .

at elevations of over 10,000 feet (3,050 m). The west slope of the Sandia Escarpment is dissected by steep drainages that provide unusual sites for certain *Abies concolor* and *Pinus ponderosa* habitat types. The long, east slope of the Sandia Mountains supports vast spruce-fir forests near the uppermost elevations, gradually changing to other forest series as elevation decreases, eventually terminating in pinyon-juniper woodlands. The Manzano Mountains support similar vegetation.

METHODS

FIELD SAMPLING

Procedures for sampling forest stands followed those of Daubenmire (1968), as modified by Moir and Ludwig (1983). Before field work began, people with knowledge of the Cibola National Forest were contacted for information on locations of mature stands. Aerial photographs, fire occurrence maps, and historical information were studied before field sampling. After on-site inspection, forest stands were subjectively selected using the following criteria: (1) a mature, self-reproducing tree canopy, (2) an undergrowth that had recovered from past disturbance (determined by the absence of plants and physical signs indicative of disturbance), and (3) a homogeneous stand that was not an ecotone between two distinctly different plant associations.

Data from selected stands were collected using one of three sampling methods: reconnaissance, analytical, and validation. The reconnaissance method was a quick and efficient sampling method compared to the detailed analytical plot method. Validation plots documented the presence of known habitat types and were similar to, but less detailed than, reconnaissance and analytical plots. Validation plots were used in the analysis of vegetation characteristics in the same manner as reconnaissance plots. The decision to use validation plots was based on whether the habitat type represented by the stand could be defined by an existing habitat type classification in the region.

Reconnaissance plots were circular (35.8 feet or 10.9 m radius) and covered 4,037 square feet (375 m^2). Canopy coverage for each undergrowth species was visually

estimated to the nearest percent. Trees were placed in the following size categories: (1) seedlings—up to 4.5 feet (1.37 m) tall, (2) small saplings—4.5 feet (1.37 m) tall to 2 inches (5.1 cm) diameter at breast height (d.b.h.), (3) large saplings/poles—2 to 10 inches (5.1 to 25.4 cm) d.b.h., and (4) mature trees—greater than 10 inches (25.4 cm) d.b.h. A prism tally was used to determine basal area. Basal area is reported in discussions of certain habitat types where it may help in identification. Because of sample size and the nonrandom nature of data collection, basal area figures should not be used to compare productivity for habitat types. Validation plots were identical to reconnaissance plots in size and data collection methods, with the exception that timber data and much of the abiotic data were not collected.

One analytical plot, 49.2 by 82.0 feet (15 by 25 m), was established for about every 10 reconnaissance plots. Both types of plots provided essentially the same information. In the analytical plots, two transect lines, 16.4 feet (5 m) apart, were placed parallel to the long axis, and 25 rectangular quadrats (7.9 by 19.7 inches or 20 by 50 cm) were spaced at 3.3-foot (1 m) intervals along each transect. Plant cover estimates were recorded in percentage coverage classes according to Moir and Ludwig (1983). The primary function of analytical plots was to provide calibration between visual estimates of reconnaissance and validation plots and the more precise measurements obtained from analytical quadrats. Also, calibration narrowed differences in estimates of cover values between investigators so that data would be comparable. To aid calibration, a reconnaissance plot always was visually estimated first on the same site where an analytical plot was measured. Results of the two methods were compared before leaving the site, and discrepancies were adjusted after further examination.

Abiotic data included location, aspect, slope, elevation, landform, and topographic position (ridge, upper slope, midslope, lower slope, bench, and streamside). The soil surface was described according to the percentage of exposed rocks, mineral soil, litter, moss and lichen, and vascular plant basal area. Evidence of historical disturbance, such as fire frequency, logging, and grazing influence, also was recorded.

DATA ANALYSIS

Initially, plots were subjectively grouped into climax forest series according to the dominant overstory species and reproduction. Within a series, individual plots were grouped according to similarities in species composition. Successive refinement was based on relevé tables—data matrices with coverage values of species in each plot (Becking 1957). Constancy was an important element determining the reliability of a species to represent a given type of habitat type. Groupings were further clarified by analyzing the total number of species in the plots, historical data, and abiotic features. Subsequent data analysis used ordination (principal component analysis) to increase objectivity, learn more about the interaction of species, substantiate earlier judgments, or reveal types not previously defined (Moir and Ludwig 1983). The process of iterative group refinement, using subjective and analytical computer procedures, was continued until stands were separated into representative units with relatively consistent site characteristics and similar tree, shrub, forb, and graminoid components. When appropriate, these units, or habitat types, were further categorized by phases. Names of habitat types were coordinated with other studies in the Southwest. Scientific names of plants follow the synonymy adopted by Fitzhugh et al.[5] (Appendix B) and common names are from Nickerson et al. (1976).

RESULTS AND DISCUSSION

The habitat types and phases of the studied portion of the Cibola National Forest are shown in table 1, and a key to their identity is in Appendix A. Six forest series are found on the Cibola National Forest: *Picea engelmannii*, *Abies lasiocarpa*, *Picea pungens*, *Abies concolor*, *Pseudotsuga menziesii*, and *Pinus ponderosa*.

Identification of 18 habitat types or phases, except for some that are common or well distributed in the study area, was based on a limited sample size consisting of less than five plots (table 1). In six instances, the small sample size resulted from the scarcity of habitat types in the study area and the difficulty in locating suitable stands in which to establish plots. Few plots were measured in the remaining 12 habitat types, merely documenting those previously identified by others, in order to concentrate sampling efforts on unknown habitat types.

Descriptions of habitat types were based on a combination of data collected from this study and information included in other classifications where sampling was more comprehensive. The classifications utilized for this purpose are those that have been developed for (1) the Apache and Gila National Forests and the Magdalena District of the Cibola National Forest[5], (2) the Lincoln National Forest (Alexander et al. 1984a), (3) the Colorado Plateau (Alexander et al. 1984b, Hanks et al. 1983), and (4) northern New Mexico and southern Colorado (DeVelice et al. 1986). The classification by Moir and Ludwig (1979) for spruce-fir and mixed conifer forests in Arizona and New Mexico also was used.

Habitat type names were standardized to ensure regional compatibility between classifications. An important exception to nomenclature standardization involved name changes of habitat types previously identified by Moir and Ludwig (1979). More intensive sampling of habitat types since their publication suggested that *Pseudotsuga menziesii* does not always attain the coclimax position in stands of *Abies concolor* forest series that was previously believed. For this reason and purposes of standardization, *Pseusotsuga menziesii* has been deleted from the names of several *Abies concolor* habitat types. Types that previously were identified by Moir and Ludwig (1979) as "*Abies concolor-Pseudotsuga menziesii*/. . ." are now "*Abies concolor*/. . ." This should be kept in mind when comparing the two classifications.

Table 1. List of Habitat Types and Phases on the Cibola National Forest, except the Magdalena District.

HABITAT NAME	ABBREVIATION	NUMBER OF PLOTS
Picea engelmannii series		
Picea engelmannii/moss habitat type	PIEN/MOSS HT	2
Abies lasiocarpa series		
Abies lasiocarpa/Acer glabrum habitat type	ABLA/ACGL HT	3
Abies lasiocarpa/Erigeron eximius habitat type	ABLA/EREX HT	7
Abies lasiocarpa/Vaccinium myrtillus habitat type	ABLA/VAMY HT	1
Picea pungens series		
Picea pungens/Carex foenea habitat type	PIPU/CAFO HT	3
Picea pungens/Cornus stolonifera habitat type	PIPU/COST HT	4
Abies concolor series		
Abies concolor/Acer glabrum habitat type	ABCO/ACGL HT	
Acer glabrum typic phase	ACGL typic P	3
Riparian phase	RIPARIAN P	3
Berberis repens phase	BERE P	5
Abies concolor/Quercus gambelii habitat type	ABCO/QUGA HT	14
Pseudotsuga menziesii series		
Pseudotsuga menziesii/Bromus ciliatus habitat type	PSME/BRCI HT	2
Pseudotsuga menziesii/Festuca arizonica habitat type	PSME/FEAR HT	4
Pseudotsuga menziesii/Muhlenbergia montana habitat type	PSME/MUMO HT	5
Pseudotsuga menziesii/Quercus gambelii habitat type	PSME/QUGA HT	2
Pinus ponderosa series		
Pinus ponderosa/Quercus gambelii habitat type	PIPO/QUGA HT	
Quercus gambelii typic phase	QUGA typic P	5
Pinus edulis phase	PIED P	12
Schizachyrium scoparium phase	SCSC P	5
Pinus ponderosa/Festuca arizonica habitat type	PIPO/FEAR HT	
Festuca arizonica typic phase	FEAR typic P	15
Bouteloua gracilis phase	BOGR P	2
Quercus gambelii phase	QUGA P	2
Pinus ponderosa/Muhlenbergia virescens habitat type	PIPO/MUVI HT	3
Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica habitat type	PIPO/MUVI-FEAR HT	1
Pinus ponderosa/Muhlenbergia montana habitat type	PIPO/MUMO HT	11
Pinus ponderosa/Bouteloua gracilis habitat type	PIPO/BOGR HT	4
Pinus ponderosa/Cinder soils habitat type	PIPO/CINDER HT	4
Pinus ponderosa/Riparian habitat type	PIPO/RIPARIAN HT	1
Pinus ponderosa/Rockland habitat type	PIPO/ROCKLAND HT	1

Each habitat type description begins with a discussion of diagnostic vegetation characterizing that type.[7] Overstory tree species are described in relation to their climax and successional roles within the habitat type, and undergrowth plant species most consistently present or absent in the habitat type are labeled "diagnostic." Other plants that are not as important as diagnostic species also are discussed if they provide clues to field identification of the habitat type. Coverage values reported in the text are based on plot averages.

A general topographical description is included in the habitat type description. However, because environmental factors may be interactive and compensating, several different topographical locations may support the same habitat type. In contrast, there are situations where a habitat type may be restricted to a particular set of topographical conditions; for example, the *Picea pungens/Cornus stolonifera* habitat type is confined to streamside benches. The habitat type descriptions also include discussions of adjacent habitat types and ecotones. A discussion section concludes the description of each habitat type and provides additional information gathered during the course of the study.

[7] *Taxonomic references were Lehr (1978), Lehr and Pinkava (1980, 1982), Martin and Hutchins (1980), and Weber and Johnston (1979).*

SPRUCE-FIR HABITAT TYPES

Picea engelmannii Series

Picea engelmannii/Moss habitat type (PIEN/MOSS HT; Engelmann spruce/moss)

Vegetation.—*Picea engelmannii* is dominant in the overstory, with mature *Abies lasiocarpa* less numerous (fig. 3). Regeneration of these two species may be abundant. *Populus tremuloides* is the major successional species present. A diagnostic feature of this habitat type

is the sparse undergrowth, which rarely exceeds 3% cover. *Vaccinium myrtillus* may be present, but usually in trace amounts. Graminoids often are absent, but *Bromus ciliatus* sometimes is present. Forbs rarely exceed 1% cover. Common species include *Aquilegia chrysantha*, *Erigeron eximius*, *Lathyrus arizonicus*, *Smilacina stellata*, and *Ramischia secunda*.

The prominent ground cover in the PIEN/MOSS HT is a thick litter layer, with mosses or lichens occurring in patches. Cover by such plants is usually about 10% but can exceed 30%.

Physical setting.—The PIEN/MOSS HT occurs in the Mount Taylor area near the top of mountain ridges, often the summit or peak. It is found on gentle or nearly flat slopes on north aspects. Elevations range from 10,500 to 11,000 feet (3,200 to 3,350 m).

Ecotones and adjacent habitats.—On Mount Taylor, the PIEN/MOSS HT is upslope from the *Abies lasiocarpa/Vaccinium myrtillus* habitat type, which is found on much steeper slopes. The PIEN/MOSS HT often is adjacent to large, open meadows of *Danthonia parryi* found in the Mount Taylor area.

Discussion.—The PIEN/MOSS HT is at the cold end of the temperature gradient for spruce-fir forests, making it one of the coldest forest habitat types on the Cibola National Forest. Within the study area, it is restricted to the Mount Taylor area.

Site disturbance results in drastic successional changes in plant composition in this habitat type. Complete overstory removal increases the shrub and graminoid layers. Species of *Ribes* and *Rubus* dominate disturbed sites. Among abundant graminoids, *Carex* and *Cyperus* are common. Common seral forbs include *Cirsium* spp., *Lathyrus arizonicus*, *Lupinus* spp., and *Vicia americana*. *Populus tremuloides* is a colonizing overstory species, with *Pseudotsuga menziesii* becoming established later. These two species provide the cooler microsite conditions necessary for establishing an understory of *Picea engelmannii* and *Abies lasiocarpa*. The high light intensity and warmer conditions of the exposed sites may restrict the establishment of these two species (Ronco 1970).

The PIEN/MOSS HT is a common habitat type of the spruce-fir forests of the Southwest (Moir and Ludwig 1979). It has been observed on higher mountain summits in the Gila National Forest[5]. The dense canopy cover and the more gentle slopes of this habitat type result in snow retention late into the spring.

Although sample size (N = 2) was small, species composition and relative abundance in the sampled plots correlated well with that found by Moir and Ludwig (1979) and by others in the Apache and Gila National Forests.[5]

Abies lasiocarpa Series

Abies lasiocarpa/Acer glabrum habitat type (ABLA/ACGL HT; subalpine fir/Rocky Mountain maple)

Vegetation.—Abies *lasiocarpa* is the dominant timber species of this habitat type (fig. 4). *Picea engelmannii* is relatively less abundant than on other *Abies lasiocarpa* series habitat types. *Pseudotsuga menziesii* and *Abies concolor* are major late-successional species, and often are present as decadent individuals in the young climax forest. *Populus tremuloides* is the major early seral species, providing the protective canopy under which mixed conifers become established.

Acer glabrum is the dominant shrub species, often occurring in tree form and dominating a portion of the lower canopy. *Symphoricarpos oreophilus* also is common. Total shrub cover averages over 10%. *Bromus ciliatus* dominates the grass cover, with coverage values as high as 60%. *Festuca sororia* is often associated with *Bromus ciliatus*. Average grass cover sampled was about 20%. *Erigeron eximius* occurs only in association with *Acer glabrum* and *Bromus ciliatus*. Other common forbs include *Aquilegia elegantula* and *Lathyrus arizonicus*. Average forb cover was over 10%.

Figure 3.—*Picea engelmannii*/Moss habitat type: La Mesa Peak (10,720 feet or 3,270 m). *Picea engelmannii* dominates the canopy, with occasional *Abies lasiocarpa*. Total shrub, grass, and forb cover is less than 5%.

Figure 4.—*Abies lasiocarpa/Acer glabrum* habitat type: Sandia Crest above Osha Spring (9,980 feet or 3,040 m). *Abies lasiocarpa* dominates the canopy but *Pseudotsuga menziesii* is abundant. *Acer glabrum* grows into canopy and is prominent on the site.

Physical setting.—The ABLA/ACGL HT was found only on the long easterly slope of the Sandia Mountains. It may occur in the Manzano Mountains, although no stands were sampled there. This type occurs between 9,700 and 10,000 feet (2,955 and 3,050 m) on northeast aspects with slopes ranging between 15% and 45%. Litter cover is high, and the soils have a well-developed layer of partially decomposed organic matter.

Ecotones and adjacent habitats.—The ABLA/ACGL HT represents the lowest elevational habitat type of the spruce-fir forests sampled in the study area. It is transitional to the ABCO/ACGL mixed conifer habitat type along its lower elevational boundary, as indicated by the prominent role of *Pseudotsuga menziesii* in the late successional stages of the ABLA/ACGL HT. The ABLA/EREX HT occurs along its higher elevation border.

Discussion.—Sample size (N = 3) for this study was small because of limited extent of this type on the Cibola National Forest. The ABLA/ACGL HT probably is closely related to the *Picea engelmannii/Acer glabrum* habitat type described earlier by Moir and Ludwig (1979). However, the ABLA/ACGL HT differs in that it may be found over a broad range of topographical situations, whereas the PIEN/ACGL HT is restricted to canyons at relatively low elevations. Although the ABLA/ACGL and PIEN/ACGL HT's exhibit similarities in undergrowth characteristics, the overstories are strikingly different. Few mature *Picea engelmannii* trees are found in stands representing the ABLA/ACGL HT.

Populus tremuloides completely dominates this habitat type during successional stages following major disturbances. *Pseudotsuga menziesii* and *Abies concolor* slowly become established and crowd aspen from the site. Finally, *Abies lasiocarpa* and *Picea engelmannii* regenerate under the 50- to 100-year-old mixed conifer canopy and eventually dominate the stand.

As with other high elevation types, the ABLA/ACGL HT is an important watershed habitat type, and because of the great diversity in shrub and herbaceous layers, it also is important summer habitat for wildlife. Water production and wildlife may benefit from small patchy-sized openings in the canopy.

Abies lasiocarpa/Erigeron eximius habitat type (ABLA/EREX HT; subalpine fir/forest fleabane)

Vegetation.—*Abies lasiocarpa* and *Picea engelmannii* are the dominant timber species in this habitat type (fig. 5). There may, however, be an inverse relationship between abundance of the two species related to stand density; *Abies lasiocarpa* appears to dominate dense stands; *Picea engelmannii* is more abundant in open stands. The successional relationship between these two species is not clear for this habitat type. *Pseudotsuga menziesii* and *Abies concolor* are present as late successional elements, but rarely as mature trees in older stands. *Populus tremuloides* is the major early seral tree species.

Vaccinium myrtillus is absent from this type, but *Symphoricarpos oreophilus* and *Berberis repens* are common. Shrub cover is low, averaging less than 2%. Mean grass cover is 8%, but increases in openings of the forest

Figure 5.—*Abies lasiocarpa/Erigeron eximius* habitat type: La Mosca Canyon (9,620 feet or 2,930 m). *Abies lasiocarpa* and *Picea engelmannii* are codominant, with scattered *Pseudotsuga menziesii*. *Erigeron eximius* and *Vicia americana* are prominent, but the shrub and grass layers are minimal.

canopy. Common graminoid species are *Bromus ciliatus* and *Carex foenea*. Frequent, but less common grasses include: *Danthonia parryi*, *Festuca arizonica*, *Festuca thurberi*, and *Trisetum montanum*.

Erigeron eximius is a constant forb species. *Aquilegia elegantula*, *Lathyrus arizonicus*, *Osmorhiza depauperata*, and *Pseudocymopterus montanus* are common. In stands where *Populus tremuloides* is abundant, *Lathyrus arizonicus* and *Vicia americana* cover can exceed 20%. Total forb cover is normally 15–20%.

Physical setting.—The ABLA/EREX HT is found throughout the Cibola National Forest on ridge slopes and uplands with 5–60% slopes. This type can be found on all aspects from 10,000 to 10,900 feet (3,050 to 3,320 m) elevation. One stand was found at a lower elevation, 9,600 feet (2,925 m), on a lower canyon slope. However, it was not determined whether this habitat type occurs at such low elevations in canyons throughout the forest. Moir and Ludwig (1979) reported the *Abies lasiocarpa/Erigeron superbus*[8] habitat type as occurring on canyon benches and streamside sites.

Ecotones and adjacent habitats.—The ABLA/EREX HT borders the *Abies lasiocarpa/Vaccinium myrtillus* habitat type or high elevation meadows along its upper borders. Where the type abuts open areas—particularly the high meadows of Mount Taylor—the grass component may be abundant, decreasing as the canopy density increases. In the Sandia Crest area, the ABLA/EREX HT borders the *Abies lasiocarpa/Acer glabrum* habitat type at lower elevations.

Discussion.—The ABLA/EREX HT is widespread on the Cibola National Forest, and it also is a common habitat type of the spruce-fir forests in Arizona and New Mexico (Moir and Ludwig 1979, Alexander et al. 1984a, DeVelice et al. 1986, Fitzhugh et al.[5]). Stands in the Cibola National Forest occur at higher elevations than those described for the other areas. Mean basal area for timber species was 217 square feet per acre (49.9 m^2/ha).

[8] *Erigeron superbus and E. eximius are synonymous (see Appendix B), and the latter is considered the acceptable name in habitat classifications in the Southwest.*

The rich herbaceous undergrowth and interspersed patches of seral *Populus tremuloides* provide important summer habitat for wildlife. Such interspersion may be maintained by fire or silvicultural practices which open the canopy. The ABLA/EREX HT also is an important watershed habitat type, because it retains snowpack late into the spring.

Abies lasiocarpa/Vaccinium myrtillus habitat type (ABLA/VAMY HT; subalpine fir/Rocky Mountain whortleberry)

Vegetation.—The overstory of the ABLA/VAMY HT is dominated by *Abies lasiocarpa* and *Picea engelmannii* (fig. 6). Regeneration often is equally divided between the two species. *Abies concolor* and *Pseudotsuga menziesii* are absent from older stands even though they sometimes attain minor successional importance in the type. *Populus tremuloides* is the major species during early succession.

Vaccinium myrtillus is the dominant shrub in this habitat type; its cover ranges from a trace to over 40% in sampled plots. Moir and Ludwig (1979) found the mean cover for *Vaccinium* in the ABLA/VAMY HT to be over 60%. They also found that common grasses include *Bromus ciliatus* and *Trisetum montanum*, but grasses often are sparse or absent. Consistent forbs are *Erigeron eximius*, *Lathyrus arizonicus*, and *Ramischia secunda*. Although *Erigeron eximius* is common in this habitat type, it always occurs in association with *Vaccinium myrtillus*.

Physical setting.—Within the study area, the ABLA/VAMY HT was found only at upper elevations of Mount Taylor on north to northwest aspects. Sites were situated on high ridges between 10,000 and 10,800 feet (3,050 and 3,290 m) elevation. The type occurs in some localities on slopes that are steeper than 60%. Litter layers are thick, and moss is often present.

Ecotones and adjacent habitats.—Stands of the ABLA/VAMY HT were found adjacent to the PIEN/MOSS HT, which is situated upslope on more gentle topography. Transition to the ABLA/VAMY HT may be rapid because of rapid changes in slope. On warmer sites, the *Abies lasiocarpa/Erigeron eximius* habitat type is adjacent.

Figure 6.—*Abies lasiocarpa/Vaccinium myrtillus* habitat type: La Mosca Peak (10,550 feet or 3,215 m). *Abies lasiocarpa* is abundant, with *Picea engelmannii* codominant. *Vaccinium myrtillus* often covers more than 25% of the ground surface; other species are not abundant.

Discussion.—The ABLA/VAMY HT is found on steep slopes in the Mount Taylor area. The overstory canopy is more open than the PIEN/MOSS HT. Sites on which the habitat type is found are well drained, giving the type a drier appearance than the PIEN/MOSS HT.

Successional stands are dominated by shrubs, and *Vaccinium myrtillus* may be replaced by *Ribes* spp. *Populus tremuloides* dominates the seral tree canopy. Spruce and fir regenerate under the *Populus tremuloides* canopy. *Abies lasiocarpa* and *Picea engelmannii* seedlings may have a higher survival rate because of the less harsh environment on north aspects where this habitat type is usually found (Ronco 1970).

The ABLA/VAMY HT is widespread, occurring in most forests of the Southwest (Moir and Ludwig 1979, DeVelice et al. 1986, Fitzhugh et al.[5]). It was not, however, found on the Lincoln National Forest in southern New Mexico (Alexander et al. 1984a). Only one plot of the ABLA/VAMY HT was found on the Cibola National Forest, which illustrates its limited occurrence here. The one plot, however, validates the occurrence of the type because of similar characteristics with plots elsewhere (Moir and Ludwig 1979, DeVelice et al. 1986, Fitzhugh et al.[5]).

MIXED CONIFER HABITAT TYPES

Picea pungens Series

Picea pungens/Carex foenea habitat type (PIPU/CAFO HT; blue spruce/silvertop sedge)

Vegetation.—*Picea pungens* and *Pseudotsuga menziesii* dominate the climax overstory and regeneration stratum of this habitat type (fig. 7). Other conifer species may be present, but vary in abundance. *Populus tremuloides* is the major successional species, often persisting into the later stages of overstory development.

Common shrubs are *Acer glabrum*, *Berberis repens*, and *Ribes* spp. Average shrub cover for the plots was 8%. *Cornus stolonifera* is often present, but showing less coverage than grasses. *Carex foenea* is abundant and dominates the undergrowth, often with cover exceeding 10%. *Festuca arizonica*, *Festuca thurberi*, and *Poa fendleriana* are all common but less abundant than *Carex foenea*. Total graminoid cover averaged 29% for the sample plots.

The forb layer is highly diverse and abundant in this habitat type. Average cover in the plots was 41%. Species of *Fragaria* are present, though not dominant in the sampled plots. Common forb species include *Achillia millefolium*, *Erigeron eximius*, *Geranium richardsonii*, *Lathyrus arizonicus*, *Pseudocymopterus montanus*, and *Vicia americana*.

Physical setting.—The PIPU/CAFO HT is restricted to cool moist canyon sideslopes. It can be found on most

aspects between 8,000 and 9,500 feet (2,440 and 2,895 m) in elevation. This elevational range may be extended if favorable microsite conditions for the habitat type are present.

Ecotones and adjacent habitats.—Adjacent habitats vary according to the canyon site occupied by the PIPU/CAFO HT. When the type occurs at higher elevations, it is adjacent to spruce-fir forests, the ABLA/EREX HT being most common. At midelevations, adjacent habitat types vary according to the aspect of the canyon slopes; warmer aspects have *Pinus ponderosa* types present; cooler aspects support *Abies concolor* types. At lower elevations, the type abuts *Pinus ponderosa* forests, commonly the *Pinus ponderosa/Festuca arizonica* habitat type (PIPO/FEAR HT).

Discussion.—This habitat type is found in the Zuni Mountains and the Mount Taylor area of the Cibola National Forest. The small sample size (N = 3) reflects its limited distribution on the Cibola. The PIPU/CAFO HT was previously identified by DeVelice et al. (1986), Moir and Ludwig (1979), and Fitzhugh et al.[5] The nomenclature of the type follows that of Fitzhugh et al.,[5] who separated the PIPU/CAFO HT of Moir and Ludwig (1979) into the PIPU/CAFO and PIPU/FEAR habitat types. Appendix E shows mean forb dominance in the PIPU/CAFO HT to be within the range of the *Picea pungens/Erigeron eximius* habitat type of Fitzhugh et al.[5] This mean value was elevated by one plot that may have actually represented the PIPU/EREX HT, but the possibility of historical disturbance prevented conclusive separation from the PIPU/CAFO HT.

Populus tremuloides is the major successional overstory species dominating sites following disturbance. Forb and grass cover, including *Festuca arizonica* and *Poa fendleriana*, increases when the canopy opens. Heavy grazing may also increase the proportion of forbs.

Because this habitat type is cool and moist (nearly riparian) and links the two opposite slopes of the canyon, it is important for wildlife, particularly big game. The topographical conditions under which this habitat type occurs creates abrupt edges between habitat types which are favorable for many kinds of wildlife. Evidence of grazing by wildlife and domestic stock was observed in this habitat type.

Figure 7.—*Picea pungens/Carex foenea* habitat type: Little Water Canyon (8,240 feet or 2,510 m). *Picea pungens* and *Pseudotsuga menziesii* dominate the canopy. *Carex foenea* is the dominant graminoid with about 20% coverage. Forbs are diverse.

Picea pungens/Cornus stolonifera habitat type (PIPU/COST HT; blue spruce/red osier dogwood)

Vegetation.—*Picea pungens* and *Pseudotsuga menziesii* are dominant in the climax overstory and as reproduction (fig. 8), but other conifer species were absent from sample plots in this habitat type. Occasional establishment of *Juniperus osteosperma* and *J. scopulorum* may occur where adjacent habitat types are much drier. *Populus tremuloides* is abundant as the early successional tree species and persists into the later stages of the stand development.

Cornus stolonifera is the dominant shrub species, often forming dense thickets covering 20% or more of a plot. *Berberis repens* and *Pachistima myrsinites* are constant species with coverage ranging from 1% to 5%. Other common shrubs include *Acer glabrum*, *Alnus tenuifolia*, *Lonicera involucrata*, *Quercus gambelii*, *Ribes* spp., *Salix* spp., and *Symphoricarpos oreophilus*. Shrubs are the dominant undergrowth component of this habitat type, showing an average cover of over 45%.

Graminoids are subordinate to shrubs with *Carex foenea* sometimes abundant, but if so, always associated with *Cornus stolonifera*. *Bromus ciliatus* and *Carex rossii* also are common. Forbs are subordinate to the shrub layer. Average cover of forbs is 17% for the samples. *Achillea millefolium*, *Lathyrus arizonicus*, *Mertensia franciscana*, *Smilacina racemosa*, *Thalictrum fendleri*, and *Vicia americana* are common.

Physical setting.—The PIPU/COST HT is restricted to canyons, streamsides, or slightly elevated benches. Water, either from perennial streams or subsurface sources, appears to be a requirement for this habitat type. It can be found between 7,500 and 8,500 feet (2,285 and 2,590 m) in elevation, but may extend outside this range if suitable water and topographic conditions are present. This type

Figure 8.—*Picea pungens/Cornus stolonifera* habitat type: East Fork Water Creek (8,200 feet or 2,500 m). *Picea pungens* is codominant with *Pseudotsuga menziesii*. *Cornus stolonifera* is the dominant low shrub.

may be found on canyon slopes, but such stands usually are ecotones.

Ecotones and adjacent habitats.—Adjacent habitat types may vary greatly because of topographic conditions under which the PIPU/COST HT occurs. The *Pinus ponderosa/Festuca arizonica* habitat type is commonly found adjacent to the PIPU/COST HT in lower elevation canyons; the ABCO/QUGA HT is associated with the type at higher elevations. Adjacent habitats vary according to the aspect of canyon slopes on which they are located. Warmer aspects favor *Pinus ponderosa* series habitat types; cooler aspects support *Abies concolor* or *Pseudotsuga menziesii* series habitat types.

Discussion.—The small sample size (N = 4) for the PIPU/COST HT reflects the limited nature of *Picea pungens* stands on the Cibola National Forest. The unusual characters which describe this stand probably warrant separate habitat type status, despite the small sample size upon which it is based. More study on *Picea pungens* stands in this Forest probably will identify additional stands representing the PIPU/COST HT. The PIPU/COST HT is found in the Zuni Mountains, along cool canyons associated with Oso Ridge. This is a newly described *Picea pungens* habitat type for southwestern forests. It is associated with surface or subsurface water. The shrub layer is three times as dense as the forb or grass components. Moir and Ludwig (1979) recognized phases of a *Picea pungens-Pseudotsuga menziesii* habitat type that were dominated by low shrubs—*Arctostaphylus uva-ursi* and *Linnaea borealis*—but none of their phases exhibited dominance by taller shrubs as in this study. Fitzhugh et al.[5] recognized only grass and forb dominated *Picea pungens* habitat types in the Gila National Forest. Mean basal area for overstory trees in the PIPU/COST HT was 178 square feet per acre (40.8 m^2/ha).

The PIPU/CAFO HT differs from the PIPU/COST HT in the relative abundance of the shrub, grass, and forb components. Within the PIPU/CAFO HT, grasses are three times as abundant as shrubs, and forbs are four times as abundant. But in the PIPU/COST HT, shrub cover is three times that of grasses and more than twice that of forbs. The PIPU/COST HT appears dependent on surface or subsurface water; the PIPU/CAFO HT is less restricted.

Wet canyon sites are crucial elements of the habitat complex of a forest because they link habitat types located on either side of the canyon. Such topographic conditions often create abrupt edges between adjacent types which have radically different plant compositions. These areas are used heavily by wildlife and provide natural fire barriers. The *Picea pungens* stands in the Zuni Mountains have received limited recreational use and are in unusually good ecological condition compared to similarly situated stands in other southwestern forests.

Abies concolor Series

Abies concolor/Acer glabrum habitat type (ABCO/ACGL HT; white fir/Rocky Mountain maple)

Vegetation.—*Abies concolor* is the dominant timber species of this habitat type, and all age classes are well represented (fig. 9). *Pseudotsuga menziesii* is codominant, and *Pinus strobiformis* and *P. ponderosa* are common. *Populus tremuloides* is the major successional species. There is a basic difference within the overstory between phases of this habitat type. Only *Abies concolor* is present in the riparian phase, while a mixture of the above species occurs in the typic and *Berberis repens* phases. *Acer negundo* is sometimes found along streamsides in the overstory of the riparian phase.

Figure 9.—*Abies concolor/Acer glabrum* habitat type: east slope of Sandia Escarpment (9,840 feet or 3,000 m). *Abies concolor* dominates, with *Pseudotsuga menziesii* co-climax and more numerous on successional sites. *Acer glabrum* is abundant, and dominating the shrub layer. *Bromus ciliatus* also is abundant, and forbs are diverse.

Acer glabrum is the dominant shrub species within this habitat type. *Quercus gambelii* is common in all phases, and average shrub cover is 38%. The grass component is less important than in other types, averaging 9% cover. The forbs are diverse, and sometimes form a dense cover blanketing the ground.

Acer glabrum (ACGL) typic phase.—The typic phase is dominated by *Acer glabrum* in the shrub layer. *Quercus gambelii* occurs from trace amounts to over 5% cover. *Bromus ciliatus* is a common graminoid and can be abundant. Common forbs include *Achillia millefolium, Heuchera parviflora, Mertensia franciscana, Osmorhiza depauperata, Valeriana capitata,* and *Vicia americana.*

Riparian phase.—The riparian phase is distinguished by the absence of conifers, other than *Abies concolor,* in the overstory; high shrub cover and restriction to streamside canyon bottoms are also characteristic. *Acer glabrum* can be found with over 50% cover, and *Jamesia americana* is abundant. *Quercus gambelii* is variable, but can have 10% or higher cover. *Symphoricarpos oreophilus* also is abundant. Graminoids are greatly reduced in comparison with other phases; *Bromus ciliatus* is the only consistent species. Forbs are not as dominant as shrubs on these sites, and cover is usually less than 10%. However, in one plot *Osmorhiza depauperata* had 40% cover, and the shrub layer, described above, covered the entire plot. Other common forbs include *Clematis pseudoalpina, Fragaria americana, Malaxis soulei, Polemonium foliosissium, Senecio eremophilus,* and *Thalictrum fendleri.*

Berberis repens (BERE) phase.—The shrub layer of the BERE phase has less *Acer glabrum* and more *Quercus gambelii* than that of the typic phase. *Quercus gambelii*, however, does not exceed 10% cover. *Berberis repens* is constant, and ranges from 1% to 10% cover. *Bromus ciliatus* is a common grass. Forbs often dominate the undergrowth on these sites. *Clematis ligusticifolia* can be dominant in this phase, with over 25% cover. Common forbs include *Artemisia franserioides*, *Fragaria americana*, *Haplopappus parryi*, *Malaxis soulei*, *Polemonium foliosissimum*, *Pseudocymopterus montanus*, *Stellaria longifolia*, and *Thalictrum fendleri*.

Physical setting.—The typic phase occurs from 8,000 to 9,500 feet (2,440 to 2,895 m) on north to northeasterly aspects. It can be found on ridges at high elevations and in cool drainages at lower elevations.

Stands of the *Berberis repens* phase occur from 8,100 to 10,300 feet (2,470 to 3,140 m) in elevation, on mostly northern aspects. The *Berberis repens* phase is found on ridge sideslopes, as well as cool, moist microsites at lower elevations. The phase was sampled only on the eastern slope of the Sandia Mountains, but may occur on northern aspects of Mount Taylor.

The riparian phase of the habitat type is restricted to perennial streamsides in steep-sided, deep, shady canyons, unless sites are protected and sufficiently moist to allow establishment along ephemeral drainages with year-long subsurface flows. Elevation ranges from 7,500 to 8,200 feet (2,285 to 2,500 m). All samples were taken from the west side of the Sandia Mountains, on a variety of microsite aspects. This phase can occur in canyons bisecting warm, south exposures, if conditions are moist and shady.

Ecotones and adjacent habitats.—The typic and *Berberis repens* phases of this habitat type can be found adjacent to the ABLA/ACGL HT. An increase in *Abies lasiocarpa* and *Picea engelmannii* signifies a change to a cooler, more mesic habitat type. At lower elevations, these phases form ecotones with the *Abies concolor/Quercus gambelii* habitat type as *Acer glabrum* disappears from the shrub layer.

The riparian phase usually is bordered by the ABCO/QUGA HT. The contrast between the two types is exemplified by the dominance of *Acer glabrum* in the ABCO/ACGL HT and an increase in conifer species in the ABCO/QUGA HT.

Discussion.—The ABCO/ACGL HT represents a transition from the ABCO/QUGA HT to types representative of spruce-fir forests. Such transition is evident on the eastern slope of the Sandia Mountains with changes in elevation. The *Berberis repens* phase is found downslope from the spruce-fir habitat types. The riparian phase is a restricted type exemplifying riparian zones in the mixed conifer forest. The *Berberis repens* phase is more extensive than the riparian phase on the Cibola National Forest.

Abies concolor and *Pseudotsuga menziesii* were moderately to heavily infected with dwarf mistletoe in many plots. Forbs and grasses increased where canopies were open. In the *Berberis repens* phase, *Robinia neomexicana* and *Populus tremuloides* invade open sites.

The ABCO/ACGL HT has been described elsewhere in the Southwest (Moir and Ludwig 1979, Alexander et al. 1984a, Fitzhugh et al.[5]). DeVelice et al. (1986) also identified the ABCO/ACGL HT in northern New Mexico, where the *Berberis repens* phase is common. Stands in the Cibola National Forest are similar to those described by the above authors, but they represent the lower elevational range of the phase. Fitzhugh et al.[5] and Alexander et al. (1984a) recognized the *Holodiscus dumosus* phase of the ABCO/ACGL HT in the Gila and Lincoln National Forests, respectively. Moir and Ludwig (1979) suggested that the *Berberis repens* phase occurs in the northern forests of the region, while the *Holodiscus dumosus* phase occurs in southern forests.

The riparian phase of this habitat type is similar to the *Abies concolor/Acer grandidentatum* habitat type of the Lincoln National Forest (Alexander 1984a). However, *Acer grandidentatum* was not found in stands on the Cibola National Forest.

Because of location in stream bottoms, riparian stands are not suitable for most timber harvesting operations. Overgrazing by livestock may result in soil loss during periods of water runoff. The phase often represents a sharply delineated, cool, moist inclusion of riparian vegetation within a much drier community. Therefore, it provides important structural diversity and thermal moderation for birds and mammals. The dense three-tiered structure of herbs, shrubs, and trees makes all phases of the habitat type important to wildlife.

Abies concolor/Quercus gambelii habitat type (ABCO/QUGA HT; white fir/Gambel oak)

Vegetation.—*Abies concolor* and *Pseudotsuga menziesii* are codominant timber species in this habitat type (fig. 10). *Abies concolor* dominates regeneration as stands mature. *P. menziesii* is a mid-successional species, becoming established earlier than *A. concolor*. *Pinus strobiformis* is minor in this habitat type in the Cibola National Forest. *Pinus ponderosa* is a major seral species; mature trees are present in older stands. *Juniperus scopulorum* is common and may indicate rocky soils.

Quercus gambelii is the dominant shrub species, and often competes with developing conifers for canopy space. Average cover for *Q. gambelii* was 10%. *Cornus stolonifera* is common, possibly because of rocky soil conditions similar to those that result in the occurrence of *Juniperus scopulorum*. *Berberis repens* and *Symphoricarpos oreophilus* also are common shrubs. Average cover for the shrub stratum is 14%. The graminoid component is sparse, with average cover about 2.5%. It is composed of ubiquitous species such as *Carex rossii*, *Muhlenbergia montana*, *Poa fendleriana*, and *Sitanion hystrix*. Forb species are equally ubiquitous, with *Thalictrum fendleri* the most common. Other forbs which are common, but lack constancy, include *Fragaria americana*, *Geranium caespitosum*, and *Lathyrus arizonicus*. Average cover for the forb layer was 2.5%.

Physical setting.—The ABCO/QUGA HT occurs on most aspects between 7,400 and 8,700 feet (2,255 to

2,650 m), representing a lower elevational range than that discussed by Moir and Ludwig (1979). This habitat type occupies a variety of topographical positions, from lower canyon sideslopes at low elevations to upper slopes near the top of ridges at higher elevations.

Ecotones and adjacent habitats.—The ABCO/QUGA HT is widespread throughout the Cibola National Forest, bordering a variety of habitats. As moisture increases and temperature decreases, the ABCO/QUGA HT adjoins the ABCO/ACGL HT with noticeable ecotones. If the moisture-temperature change is abrupt, the ABLA/VAMY HT occurs next to the ABCO/QUGA HT, although such situations are uncommon. The *Pseudotsuga menziesii/Muhlenbergia montana* habitat type is commonly found where adjacent locations are drier. *Pinus ponderosa* habitat types are sometimes present on adjacent sites, particularly where environmental conditions become abruptly drier and warmer.

Discussion.—Data for the ABCO/QUGA HT were collected from areas adjacent to the Sandia and Manzano Mountains. The Zuni Mountains and the Mount Taylor region have relatively little area occupied by this habitat type and were not sampled. The narrow transition zone between the *Pseudotsuga menziesii* series and the *Abies lasiocarpa* series on Mount Taylor allows little representation of the *Abies concolor* series.

This habitat type, although not prominent on the Cibola National Forest, is extensive in New Mexico. *Pinus ponderosa* is an important commercial species and is a successional species in this type. However, Moir and Ludwig (1979) found that *Pinus ponderosa* exhibited poor to good growth potential in this habitat type. *Pseudotsuga menziesii* also is an important mid-successional species and persists into the latter stages of stand development. Mean basal area for the timber species was 126 square feet per acre (29 m^2/ha).

Festuca arizonica and *Muhlenbergia virescens* were absent from plots in the Cibola National Forest. However, both species denote respective phases of the ABCO-PSME/QUGA HT (equivalent to the ABCO/QUGA HT) found elsewhere by Moir and Ludwig (1979). Similarly, *Holodiscus dumosus* occurred in trace amounts on three of the ABCO/QUGA HT plots in this study, but its presence is believed to be accidental and not indicative of the HODU phase found on the Lincoln National Forest (Alexander et al. 1984a).

Figure 10.—*Abies concolor/Quercus gambelii* habitat type: Pino Canyon, west slope Sandia Escarpment (8,160 feet or 2,490 m). *Abies concolor* and *Pseudotsuga menziesii* are codominant, with *Pinus ponderosa* subordinate. *Quercus gambelii* is the dominant shrub, often reaching tree size. Grasses and forbs are diverse, but their cover values are low.

The major disturbance affecting the ABCO/QUGA HT is fire. Dense shrub layers lead to well-developed fuel ladders and severe fires. As a consequence, *Quercus gambelii* sprouts profusely within these burned areas, and results in persistent oak stands that compete with conifers, often *Pinus ponderosa*, during stand development. *Pseudotsuga menziesii* and *Abies concolor* reproduction may be killed by low intensity fires during early successional stages, creating a disclimax of the more fire resistant *Pinus ponderosa*. However, after a few years, *Pseudotsuga menziesii*, with its thicker bark, can withstand such low intensity fires.

Some slopes supported alternate strips of pinyon-juniper, *Abies concolor*, and brushy *Quercus gambelii* stands that were oriented perpendicular to the contour of the slope, apparently reflecting fires of different intensities or seasons. Erosion may be severe on slopes in this type when litter and overstory are removed. Several stands were identified as former *Pinus ponderosa-Juniperus deppeana*, or *Pinus ponderosa-Quercus gambelii* fire disclimaxes, where *Abies concolor* increased after intensive fire control measures began.

Pseudotsuga menziesii Series

Psuedotsuga menziesii/Bromus ciliatus habitat type (PSME/BRCI; Douglas-fir/fringed brome)

Vegetation.—*Pseudotsuga menziesii* is the dominant timber species in all age classes (fig. 11). *Pinus strobiformis* and *P. ponderosa* are minor components, and *Abies concolor* is absent.

Acer glabrum was present in the two plots sampled. Coverage values ranged from 5% to 10%. *Holodiscus dumosus* was common but had low coverage values. The shrub layer was minor in comparison with graminoids, which covered the entire surface of the plots. *Bromus ciliatus* was a constant graminoid in this habitat type; *Carex foena*, *C. rossii*, and *Trisetum montanum* were abundant. The forb layer also was well represented, at times covering more than 50% of a plot. *Campanula rotundifolia*, *Clematis pseudoalpina*, *Fragaria americana*, *Lathyrus leucanthus*, *Ligusticum porteri*, *Pseudocymopterus montanus*, *Thalictrum fendleri*, and *Valeriana capitata* were abundant. Total cover for undergrowth species often exceeded 100% in stands of this habitat type.

Physical setting.—This habitat type was found at Mount Taylor and the Manzano Mountains, isolated in upper reaches of canyons and on wet ridges. Pockets of deep snow or ground seepage may account for the abundant vegetation. Sites were on north aspects between 9,000 and 9,500 feet (2,745 and 2,895 m). Some slopes were steeper than 50%.

Ecotones and adjacent habitats.—The PSME/BRCI HT lies above the ABCO/ACGL HT which is found on moist, cool drainages. Upslope, the ABCO/QUGA HT was commonly found.

Discussion.—The PSME/BRCI HT is a high elevation, cool moist habitat type of the *Pseudotsuga menziesii* series. It was found on sites where environmental conditions restricted the establishment of spruce-fir or mixed conifer forests.

After major disturbances, *Populus tremuloides* is the major successional tree species of this habitat type. *Bromus ciliatus, Lathyrus* spp., and *Vicia americana* later increase under the aspen, dominating the undergrowth. Eventually, *Pseudotsuga menziesii* will replace aspen. *Acer glabrum* follows as a late successional species after *Pseudotsuga menziesii* is established.

Fitzhugh et al.[5] described this habitat type in the Magdalena Ranger District of the Cibola National Forest and in the Mogollon Mountains of the Gila National Forest. Both sample plots in this study had prominent shrub layers in which *Acer glabrum* was dominant; Fitzhugh et al.[5], however, reported that its presence was variable on the Gila National Forest. This study and the one by Fitzhugh et al.[5] reported a dense undergrowth in this habitat type which often exceeds 100% coverage.

Sites on which this habitat type was found in this study differed somewhat from those described by Fitzhugh et al.[5] In this study, plots were located in protected pockets on upper canyon slopes, while in the southern range of the San Mateo Mountains, Fitzhugh et al.[5] found the habitat type along exposed ridges. The difference may be because both plots in this study were below the 9,600–10,100 feet (2,925–3,080 m) elevational range reported by Fitzhugh et al.[5] At these lower elevations, the protected pockets may have compensated for the greater amount of snowfall found along higher elevation ridges.

Figure 11.—*Pseudotsuga menziesii/Bromus ciliatus* habitat type: Capilla Peak (9,160 feet or 2,790 m). *Pseudotsuga menziesii* is dominant, and *Pinus strobiformis* is scattered through the stand. *Acer glabrum* often is abundant in the shrub layer. *Bromus ciliatus* dominates the grass layer, and the forb component is diverse with high coverage values.

Figure 12.—*Pseudotsuga menziesii/Festuca arizona* habitat type: Capilla Peak (9,020 feet or 2,750 m). *Pseudotsuga menziesii* dominates, with *Pinus ponderosa* successional, but persisting into later seral stages. *Quercus gambelii* often is present in the shrub layer. *Festuca arizonica* is the dominant graminoid, but *Carex rossii* somtimes is abundant.

Pseudotsuga menziesii/Festuca arizonica habitat type (PSME/FEAR HT; Douglas-fir/Arizona fescue)

Vegetation.—*Pseudotsuga menziesii* is dominant in all age classes; seedlings and small saplings sometimes exceed 200 stems per acre (494/ha) (fig. 12). Regeneration by other species, however, is poor. *Abies concolor* is absent or accidental except along ecotones, while *Pinus strobiformis* is minor or absent. *Pinus ponderosa* is a major seral species, with mature trees persisting in older stands. *P. ponderosa* increases in abundance near transitions with *P. ponderosa* habitat types. *Populus tremuloides* is the major early successional species at upper elevations on cool, moist sites.

The shrub layer of this habitat type is sparse; total cover is less than 5%. *Quercus gambelii* is the most common species, and *Acer glabrum, Berberis repens,* and *Holodiscus dumosus* occasionally are present. The grass stratum is very well developed; total coverage being over 40% in some plots, with an average of 25%. *Festuca arizonica* is the dominant species. Other common graminoids include *Bromus ciliatus, Carex rossii, Koeleria nitida, Muhlenbergia montana, Poa fendleriana,* and *Sitanion hystrix.* In contrast to the shrub-dominated *Abies concolor* types, grasses are characteristic of *Pseudotosuga menziesii* habitat types on the Cibola National Forest. There was little diversity and coverage of forbs in this habitat type. Nearly constant species included *Campanula rotundifolia, Lathyrus arizonicus,* and *Vicia americana.*

Physical setting.—The PSME/FEAR HT can be found on all aspects, from 8,500 to 9,500 feet (2,590 to 2,895 m). It is less common on north aspects, however, where it may be replaced by the ABCO/QUGA HT. It is found near the crest of steep ridges; some plots have slopes steeper than 50%. All stands, except one from the Manzano mountains, were found on Mount Taylor.

Ecotones and adjacent habitats.—The PSME/FEAR HT borders the *Abies concolor* series, usually the ABCO/

QUGA HT, at upper elevations. This transition is from the grass dominated habitat type, PSME/FEAR, to a shrub-dominated type, ABCO/QUGA. Under mesic conditions, the PSME/FEAR HT adjoins the ABCO/ACGL HT. The PSME/FEAR HT is a common habitat type. It is often found on steep, upper, south-facing slopes of canyons, and occasionally occurs far enough downslope to border cool, moist *Picea pungens* habitat types in lower canyons. Transitions to *Picea pungens* types reflect abrupt environmental changes. Because of the isolated nature of *Pseudotsuga menziesii* stands in the Southwest, no situations were observed where the PSME/FEAR HT bordered other habitat types in the *Pseudotsuga menziesii* series. The lower elevational boundary of this habitat type is adjacent to the PIPO/FEAR HT.

Discussion.—The PSME/FEAR HT is the most extensive habitat type of the *Pseudotsuga menziesii* series on the Cibola National Forest. It is abundant on Mount Taylor in the San Mateo Mountains, but probably occurs in the Zuni Mountains as well. The habitat type has been previously described elsewhere (Moir and Ludwig 1979, Alexander et al. 1984b, DeVelice et al. 1986, Fitzhugh et al.[5]).

The description of the PSME/FEAR HT by Moir and Ludwig (1979) differs slightly from that given here. Stands from this study showed abundant regeneration of *Psuedotsuga menziesii* and represented a lower elevational range for the habitat type. Fitzhugh et al.[5] also described the PSME/FEAR HT throughout the Gila National Forest and the Magdalena District of the Cibola National Forest. In contrast to their descriptions, the PSME/FEAR HT reported in this study for the northern portion of the Cibola National Forest differed as follows: *Abies concolor* was absent except in ecotones, *Muhlenbergia virescens* was absent, and *Pinus strobiformis* was minor to accidental. Also, unlike the Gila National Forest, plots on the Cibola National Forest were not adjacent to other *Pseudotsuga menziesii* habitats; instead, ecotones with habitat types of other forest series were observed. Alexander et al. (1984b) reported a similar situation for the PSME/FEAR HT in northern Arizona.

Successional sequences are unclear within the PSME/FEAR HT. *Pinus ponderosa* and *Pseudotsuga menziesii* maintain themselves under repeated light fires. If *Pinus ponderosa* is fire resistant at an earlier age, periodicity of fire may be important in influencing stand dominance. *Populus tremuloides* is the major early successional species that dominates wetter sites of this habitat type after disturbance. Within the more common, drier sites, a grassy undergrowth with a sparse overstory canopy develops after disturbance to the canopy.

Pseudotsuga menziesii/Muhlenbergia montana habitat type (PSME/MUMO HT; Douglas-fir/mountain muhly)

Vegetation.—*Pseudotsuga menziesii* is the dominant timber species of the overstory, but *Pinus ponderosa* may be codominant, usually in late successional stands (fig. 13). *Pinus strobiformus* often is abundant, but may be absent from some stands. *Abies concolor*, *Pinus edulis*, and *Juniperus deppeana* are accidental.

Figure 13.—*Pseudotsuga menziesii/Muhlenbergia montana* habitat type: Mt. Sedgwick (8,640 feet or 2,635 m). *Pseudotsuga menziesii* dominates, with *Pinus ponderosa* sometimes codominant. *Pinus strobiformis* is a minor climax tree. *Muhlenbergia montana* is abundant, and the forb layer is variable.

The shrub component varies. No species showed high constancy. *Berberis repens* and *Quercus gambelii* are common, but rarely exceeded 5% cover in the stands sampled. *Muhlenbergia montana* is the most consistent undergrowth species in the habitat type, with between 1% and 5% cover. *Festuca arizonica* and *Muhlenbergia virescens* are notably absent. Other common graminoids include *Carex rossii*, *Koeleria nitida*, *Poa fendleriana*, and *Sitanion hystrix*. Average cover for grasses was 5% in this study; average forb cover was 8%. Common forbs include *Artemisia ludoviciana*, *Lithospermum multiflorum*, *Pseudocymopteris montanus*, *Senecio neomexicanus*, and *Thalictrum fendleri*.

Physical setting.—The PSME/MUMO HT is found on ridges of upper, mid, and lower slopes. It ranges from 8,000 to 9,000 feet (2,440 to 2,745 m) in elevation.

Ecotones and adjacent habitats.—The PSME/MUMO HT has been found adjacent to the *Pinus ponderosa/Muhlenbergia montana* habitat types (PIPO/MUMO HT) and the PIPO/FEAR HT. PSME/MUMO occurs over a broad range of environmental conditions, as indicated by the close association of this type with the two *Pinus ponderosa* habitat types. In general, the PIPO/FEAR HT is found on relatively more moist sites than the PIPO/MUMO HT. As elevation increases, the PSME/MUMO HT is replaced by the ABCO/QUGA HT, reflecting a shift from habitat types dominated by grass to those dominated by shrubs.

Discussion.—The PSME/MUMO HT was found only near Mount Sedgwick toward the eastern edge of the Zuni Mountains. Site quality is moderate to poor for *Pinus ponderosa*, and poor for *Pseudotsuga menziesii*. Other than obvious overstory differences, the PSME/MUMO HT is distinguished from the *Pinus ponderosa* types by the abundance of forbs and the shared dominance of the shrubs and graminoids, indicating a more mesic character.

Sites on which the habitat type grows may support a disclimax *Pinus ponderosa* overstory when subjected to frequent fires. Also, *Pinus strobiformis* occurred on some

sites as a mid- to late-successional species. Disturbances that create openings in the canopy may result in increased coverage of graminoids, primarily *Muhlenbergia montana* and *Poa fendleriana*. More mesic sites supported increased shrub cover, while xeric sites supported more grasses.

The PSME/MUMO HT also has been described for the Gila National Forest by Fitzhugh et al.[5] Many of the plots sampled by these authors were from the southern portion of the Cibola National Forest, in the San Mateo Mountains.

Pseudotsuga menziesii/Quercus gambelii habitat type (PSME/QUGA HT; Douglas-fir/Gambel oak)

Vegetation.—*Pseudotsuga menziesii* is the dominant timber species (fig. 14). Other conifers usually are absent from older stands. *Pinus ponderosa* can occur in early successional stands, with *Juniperus scopulorum* a subordinant in the lower portion of the canopy. *Quercus gambelii* also will grow to tree form and assume patchy dominance within that part of the canopy.

The shrub layer is dominated by *Quercus gambelii* with coverage values commonly over 20%. *Berberis repens*, *Pachystima myrsinites*, *Ribes cereum*, and *Symphoricarpos oreophilus* are common but less abundant than *Quercus gambelii*. The graminoids are a minor element in this type, and *Bromus ciliatus*, *Carex geophila*, *Poa fendleriana*, and *Sitanion hystrix* are common. Forbs are highly variable; species that favor cooler sites are most common. *Erigeron speciosus*, *Fragaria americana*, *Galium boreale*, *Lathyrus arizonicus*, and *Mertensia franciscana* were abundant but not constant.

Physical setting.—The PSME/QUGA HT was found in canyons at mid-elevations ranging from 7,500 to over 8,500 feet (2,285 to over 2,590 m) and on all aspects. The ground surfaces of sampled plots were rocky and covered with a shallow litter layer. All plots were on heavily fractured limestone parent material. The critical limitation to the occurrence of this habitat type is the availability of cool canyon sites.

Figure 14.—*Pseudotsuga menziesii/Quercus gambelii* habitat type: Lookout Mt. (8,580 feet or 2,615 m). *Pseudotsuga menziesii* is often the only tree present. *Pinus ponderosa* is seral. *Quercus gambelii* dominates the shrub layer, and *Berberis repens* is common. *Poa fendleriana* and *Sitanion hystrix* are common grasses.

Ecotones and adjacent habitats.—The PSME/QUGA HT was found adjacent to habitat types of the ponderosa pine series, often the PIPO/FEAR HT. The PSME/QUGA HT of the Cibola National Forest is distinct from other *Psuedotsuga menziesii* habitat types, because it occurs in cool canyons which are adjacent to warmer forest types.

Discussion.—Only two plots of the PSME/QUGA HT were found on the Cibola National Forest, and both were in the Zuni Mountains. However, they clearly confirmed the identity of the habitat type described in earlier studies in the Southwest (Alexander et al. 1984a, Alexander et al. 1984b, Fitzhugh et al.[5]). The stands on the Cibola are most likely the typic phase of this habitat type. The sites are located in topographic situations similar to that described for the PSME/QUGA HT in northern Arizona (Alexander et al. 1984b), where it was found along cool drainages of the Mogollon Rim. This habitat type is not restricted to canyon sites in other areas (Alexander 1984a, Fitzhugh et al.[5]).

The site quality of the PSME/QUGA HT for timber production is poor, and stands can be heavily infected with mistletoe. Soils are shallow and likely to be damaged by most management activities.

PONDEROSA PINE HABITAT TYPES

Pinus ponderosa Series

Pinus ponderosa/Quercus gambelii habitat type (PIPO/QUGA HT; ponderosa pine/Gambel oak)

Vegetation.—The timber overstory is dominated by *Pinus ponderosa* (fig. 15). Other timber species are noticeably absent. In mature stands, *Quercus gambelii* in tree form will dominate the lower part of the canopy. Three phases are recognized for this habitat type: *Quercus gambelii* (QUGA) typic phase, *Pinus edulis* (PIED) phase, and the *Schizachyrium scoparium* (*Andropogon scoparius*) (SCSC) phase. In the *Pinus edulis* phase, *Pinus edulis* and *Juniperus deppeana* are abundant. These two species also are common in the *Schizachyrium scoparium* phase, but are not as constant as they are in the *Pinus edulis* phase. Both are absent from the typic phase.

Quercus gambelii (QUGA) typic phase.—The shrub layer of the typic phase is dominated by *Quercus gambelii*, which exhibits cover values consistently greater than 5% and often more than 25%. *Quercus gambelii* often occurs as patchy clumps throughout the stand. *Berberis repens* shows high constancy with a trace to 5% cover.

There are three consistent graminoid species present in this phase: *Muhlenbergia montana*, *Poa fendleriana*, and *Sitanion hystrix*. These species together maintain 1% to 5% cover, occasionally over 10%, but always less than the cover of *Quercus gambelii*. *Festuca arizonica* and *Muhlenbergia virescens* are absent.

Forbs show little constancy. *Bahia dissecta*, *Lithospermum multiflorum*, and *Senecio neomexicanus* are common, but usually in trace amounts.

Pinus edulis (PIED) phase.—*Quercus gambelii* is the dominant shrub, but cover values, rarely over 20%, tend to be lower than in the typic phase. *Berberis repens* is uncommon and is rarely over 1% cover. Common shrubs include *Cercocarpus montanus*, while *Quercus undulata* and *Yucca* spp. occur under drier conditions.

Poa fendleriana and *Sitanion hystrix* are the most consistent graminoid components, and *Muhlenbergia montana* is absent or minor in cover. *Bouteloua gracilis* is also common, but rarely with more than 1% cover. Total graminoid cover is less than that of shrubs.

Forbs are a minor aspect of the undergrowth, with cover rarely exceeding 1%. *Artemisia ludoviciana*, *Eriogonum racemosum*, *Penstemon* spp., and *Senecio neomexicanus* are common species present.

Schizachyrium scoparium (SCSC) phase.—Shrub species, other than *Quercus gambelii*, are uncommon and exhibit low coverage values. The graminoid component of the SCSC phase is well developed, with total coverage values equal to or often exceeding that of the shrubs. *Schizachyrium scoparium* is diagnostic, with coverage values ranging from 1% to 10%. *Koeleria nitida*, *Muhlenbergia montana*, *Poa fendleriana*, and *Sitanion hystrix* are all common; coverage values are 1% or higher. *Muhlenbergia montana* often has greater than 5% coverage. Total graminoid coverage averaged 15% for the sampled stands. Forbs are minor, with *Lotus wrightii*, *Penstemon* spp., and *Senecio neomexicanus* common.

Physical setting.—The PIPO/QUGA HT can be found in a variety of topographic situations—canyons, ridges, and mesas. The typic phase occurs between 7,500 and 8,500 feet (2,285 and 2,590 m), on all aspects. Soil is sometimes exposed on the site, usually where an oak canopy is lacking. However, litter cover normally averages 92%. The PIED phase is more consistently found at lower elevations than the typic phase—between 7,200 and 8,200 feet (2,195 and 2,500 m). It is in canyon bottoms at the lower end of this elevational range. Rock cover increases in the PIED phase, ranging from 5% to over 25%, with litter coverage averaging 87% for the measured plots. The SCSC phase occurs between 7,400 and 8,500 feet (2,255 and 2,590 m) and occupies sites on rocky ridges. Rock cover averages 35% over a range of 17–60%. Litter cover is reduced to an average of 61%.

Figure 15.—*Pinus ponderosa/Quercus gambelii* habitat type: Sinking Spring Canyon (8,230 feet or 2,510 m). *Pinus ponderosa* dominates the canopy. *Quercus gambelii* is the dominant shrub in a low canopy.

Ecotones and adjacent habitats.—The PIPO/QUGA HT is adjacent to other habitat types of the *Pinus ponderosa* series, often the PIPO/FEAR HT. At lower elevations, the PIED phase of the habitat type usually is found next to pinyon-juniper woodlands. At higher elevations, the PIPO/QUGA HT ajoins the ABCO/QUGA HT where transitions to more mesic conditions are abrupt.

Discussion.—The PIPO/QUGA HT is common throughout the Cibola National Forest, where the most extensive stands are in the Zuni Mountains near Oso Ridge. The PIED phase is prevalent in canyons on the west escarpment of the Sandia Crest and in the Manzano Mountains.

This habitat type represents a shrub dominated *Pinus ponderosa* habitat type, as distinguished from grass types such as the PIPO/FEAR HT. Although the SCSC phase of the habitat type has a well-developed graminoid component, it also has a prominent shrub layer.

The PIPO/QUGA HT discussed here has been described by others (Alexander et al. 1984a, DeVelice et al. 1986, Fitzhugh et al.[5]), reflecting its widespread occurrence throughout southwestern forests. Many PIPO/POFE communities identified by Hanks et al. (1983) are really PIPO/QUGA HTs according to Fitzhugh et al.[5] The type occurs in northern Arizona, but it is more common in New Mexico forests.

Although the habitat type occurs throughout the Southwest, the various phases are distinctly associated with specific National Forests. For example, both the typic and the *Pinus edulis* phases were identified on the Cibola National Forest, as well as the Carson and Santa Fe National Forests in northern New Mexico by DeVelice et al. (1986). In contrast, the *Festuca arizonica* phase was found in northern New Mexico but not on the Cibola National Forest. Similarly, Fitzhugh et al.[5] identified the *Muhlenbergia longiligula* phase on the Gila National Forest, but it was not found on the Cibola National Forest.

The SCSC phase of the PIPO/QUGA HT is defined here for the first time in the Southwest; it represents a rocky environment of the habitat type. The PIPO/QUGA HT tended to occur on rocky and harsh sites in the Cibola National Forest, which is similar to its occurrence in northern Arizona (Hanks et al. 1983).

Pinus ponderosa/Festuca arizonica habitat type (PIPO/FEAR HT; ponderosa pine/Arizona fescue)

Vegetation.—*Pinus ponderosa* is the dominant timber species (fig. 16). Regeneration can be heavy—over 300 stems per acre (740/ha). *Pinus edulis* often is abundant in size classes less than 2 inches (5.1 cm) d.b.h., but it is not consistently present. *Juniperus deppeana* is common; however, it usually occurs along the ecotone with pinyon-juniper woodland.

Quercus gambelii can dominate the shrub layer, although total shrub cover is less than that of grasses. Graminoids dominate the undergrowth, and *Festuca*

arizonica is the dominant species. Forbs are a minor element of the undergrowth.

Festuca arizonica (FEAR) typic phase.—*Festuca arizonica* dominates the undergrowth with an average cover of 13%. *Muhlenbergia montana* and *Poa fendleriana* are common and can dominate sites following disturbance. Other common grasses and sedges include *Carex rossii*, *Koeleria nitida*, and *Sitanion hystrix*. Shrubs which can be common are *Ceanothus fendleri*, *Quercus gambelii*, and species of *Ribes*. However, shrubs rarely have more than trace coverage. Forb cover averaged 8% on the plots. Common species include *Antennaria parviflora*, *Erigeron flagellaris*, *Lotus wrightii*, and *Senecio neomexicanus*.

Bouteloua gracilis (BOGR) phase.—*Pinus edulis* often dominates the reproduction stage, and may become codominant with *Pinus ponderosa*. *Juniperus deppeana* is a minor species. The undergrowth is dominated by *Festuca arizonica; Bouteloua gracilis* is consistent with coverage values varying from a trace to 2%. The shrub layer is minimal and *Quercus gambelii* is often absent. *Yucca angustissima*, *Y. baccata*, and *Y. schottii* are found within this phase. Forbs include *Antennaria parviflora*, *Erigeron flagellaris*, and *Senecio neomexicanus*.

Quercus gambelii (QUGA) phase.—*Abies concolor* and *Pseudotsuga menziesii* are accidental trees along ecotones with mixed conifer forests. The undergrowth is dominated by grasses, *Festuca arizonica* being the most abundant. *Muhlenbergia montana*, *Poa fendleriana*, and *Sitanion hystrix* also are common. The shrub layer differs from that of other phases in that *Quercus gambelii* in tree form becomes a part of the lower overstory canopy. Other shrub species are rare or occur only in trace amounts.

Physical setting.—The typic phase is found on lower to upper slopes of ridges at elevations from 7,900 to 9,500 feet (2,410 to 2,895 m). All aspects are represented and slopes vary from slight to steep (over 40%). The mean cover for exposed rock was 15%, for litter 81%. The QUGA phase ranges from 7,500 to 9,500 feet (2,285 to 2,895 m) on ridges, and occurs on all aspects and on moderate slopes. The BOGR phase is found between 7,300 and 8,500 feet (2,225 and 2,590 m) in elevation and on all aspects of moderate (30%) to steep (56%) slopes. Bare rock cover, mostly composed of fractured basalt, sometimes approached 50%.

Figure 16.—*Pinus ponderosa/Festuca arizonica* habitat type: Cottonwood Creek (8,120 feet or 2,475 m). *Pinus ponderosa* is dominant; other large conifers are absent or accidental. The shrub layer is noticeably reduced; *Ribes* species and *Quercus gambelii* sometimes are present. *Festuca arizonica* is abundant, and *Carex rossii* common. Forbs are abundant, with *Achillia millifolium* and *Pseudotcymopterus montanus* often common.

Ecotones and adjacent habitats.—At high elevations, the typic phase of the PIPO/FEAR HT is adjacent to habitat types characteristic of mixed conifer forests: PSME/MUMO HT, PSME/FEAR HT, or the ABCO/QUGA HT. Lower elevations support ecotones with a variety of *Pinus ponderosa* habitat types and pinyon-juniper woodlands. On mesas near Mount Taylor, the typic phase of the PIPO/FEAR HT can be found in isolated patches on volcanic hills surrounded by pinyon-juniper woodlands. The QUGA phase is adjacent to the typic phase in transitional areas with the mixed conifer forest. Hanks et al. (1983) noted that the QUGA phase can be found on rocky outcroppings in northern Arizona. The BOGR phase is found near pinyon-juniper woodlands and may exist as isolated pockets within woodlands where *Pinus ponderosa* becomes established.

Discussion.—Because of abundant grasses, the FEAR phase of this habitat type is commonly grazed. Heavy grazing may cause a shift in abundance to *Muhlenbergia montana*, *Poa fendleriana*, and *Sitanion hystrix*, depending on the season and intensity of grazing. The sites are highly productive for timber as well.

Although few plots were sampled (N = 2), enough information was provided to validate the presence of the BOGR phase by comparing the limited data with that of other studies where sampling was more intense (Hanks et al. 1983, DeVelice et al. 1986, Fitzhugh et al.[5]). The prominent graminoid cover in the BOGR phase of the PIPO/FEAR HT promotes use by livestock. Competition between *Pinus edulis* and *Pinus ponderosa* may occur and result in lower productivity for *P. ponderosa*. Hanks et al. (1983) and Fitzhugh et al.[5] describe further the response of this habitat type to grazing.

Similarly, the occurrence of the QUGA phase was validated by comparison with studies by Hanks et al. (1983) and Fitzhugh et al.[5] The QUGA phase of the PIPO/FEAR HT is susceptible to oak competition after disturbance. Crown fires or heavy overstory removal may result in the establishment of oak brush thickets and hinder conifer reestablishment. The grass undergrowth will respond to early-season grazing pressure by a shift in composition from the dominant *Festuca arizonica* to increasing amounts of *Muhlenbergia montana* and *Poa fendleriana*. This phase is important for wildlife because of greater stand diversity, food production, and high cover densities.

Pinus ponderosa/Muhlenbergia virescens habitat type (PIPO/MUVI HT; ponderosa pine/screwleaf muhly)

Vegetation.—*Pinus ponderosa* is the dominant timber species, with individuals widely scattered (fig. 17). Regenerating trees are few, often less than or equal to the

number of mature stems. *Pinus edulis* is present in smaller size classes and often equals the number of *Pinus ponderosa* stems. *Juniperus deppeana* may be present, particularly on the higher elevation sites. Mean basal area for the sample was 65 square feet per acre (14.9 m^2/ha).

The shrub layer varies, but *Quercus undulata* and *Ceanothus fendleri* are common. Total shrub cover rarely exceeds 5%. Graminoid species dominate sites of this habitat type. *Muhlenbergia virescens* is diagnostic, with coverage values over 10%, often appearing in patchy clumps within the stand. *Bouteloua gracilis, Carex* spp., *Poa fendleriana, Schizachyrium scoparium*, and *Sitanion hystrix* are all common, but coverage value for each rarely exceeds 1%. Total grass cover averaged 19% for the sampled plots. *Festuca arizonica* is absent. Forbs are sparse and usually account for less than 1% of the stand cover. Common species are *Hieracium fendleri, Lotus wrightii, Senecio neomexicanus*, and *Sisymbrium* spp.

Physical setting.—This type is found on lower to upper slopes of ridges from 7,500 to 8,500 feet (2,285 to 2,590 m). It occurs on all aspects and on shallow to steep slopes. Exposed soil and rock are prevalent on the ground surface in these stands. Litter is most common around grass patches.

Ecotones and adjacent habitats.—Comparison of PIPO/MUVI HT stands on the Cibola National Forest with those from other areas (Hanks et al. 1983, Fitzhugh et al.[5]) suggest that the environment is drier here than elsewhere. Adjacent habitats include pinyon-juniper woodlands at lower elevations. Other ponderosa pine types, commonly the PIPO/QUGA HT and *Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica* habitat type, are adjacent to the PIPO/MUVI HT at the upper end of the habitat type range. Hanks et al. (1983) and Fitzhugh et al.[5] also found this type next to mixed conifer forests.

Discussion.—Stands of this habitat type were found in the eastern Zuni Mountains near Bonita Canyon. One stand, near McGaffey Lookout, represented the higher elevational range of the type. On the Cibola National Forest, the type has been identified as the typic phase described in other studies (Hanks et al. 1983, Fitzhugh et al.[5]).

Figure 17.—*Pinus ponderosa/Muhlenbergia virescens* habitat type: McGaffy Lookout (8,160 feet or 2,490 m). *Pinus ponderosa* dominates, with *Juniperus deppeana* and *Pinus edulis* subordinant. *Quercus gambelii* sometimes is present, but the shrub layer usually is minor. *Muhlenbergia virescens* is the dominant grass, while the forb layer is minor.

Figure 18.—*Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica* habitat type: Little Water Canyon (8,320 feet or 2,535 m). *Pinus ponderosa* is the dominant overstory species, with other species accidental or rare. *Quercus gambelii* and *Berberis repens* are common in the shrub layer. *Festuca arizonica* and *Muhlenbergia virescens* are the common grass species, their codominance being diagnostic for this type. Forb constancy is variable.

The PIPO/MUVI HT of the Cibola National Forest is a sparsely timbered type on cobbly soils. Both the study by Hanks et al. (1983) and that of Fitzhugh et al.[5] showed a higher number of small *Pinus ponderosa* trees and denser timber stands than the present study.

The PIPO/MUVI HT is grass dominated and exhibits xeric features of the moisture gradient where *Pinus ponderosa* dominates. Fitzhugh et al.[5] found that site conditions for this habitat type were drier in southern New Mexico than in Arizona. In contrast, Hanks et al. (1983) identified the PIPO/MUVI HT as the most mesic ponderosa pine type in northern Arizona. Stands on the Cibola National Forest illustrate the driest range of the PIPO/MUVI HT, being found adjacent to pinyon-juniper woodlands. This variation in ecological position may represent a consistent geographical shift from southwest to northeast New Mexico and from west to east throughout its range.

Successional trends in stands of the PIPO/MUVI HT were not clear. It is possible that *Pinus edulis* may increase with fire exclusion, but *Pinus ponderosa* would still be present. Fuel levels are low, reducing fire intensities and creating patchy burns. Grazing likely would lead to a decrease in *Muhlenbergia virescens* and an increase in *Bouteloua gracilis* and *Poa fendleriana*, particularly with early season grazing.

Pinus ponderosa/Muhlenbergia virescens-Festuca arizonica habitat type (PIPO/MUVI-FEAR HT; ponderosa pine/screwleaf muhly-Arizona fescue)

Vegetation.—*Pinus ponderosa* is the dominant timber species. All other conifer species are accidental or rare (fig. 18). *Quercus gambelii* is the dominant tall shrub, and *Berberis repens* also is common.

Graminoids dominate the undergrowth of this habitat type; both *Festuca arizonica* and *Muhlenbergia virescens* are abundant. Their codominance is diagnostic for this type. Other common species include *Carex rossii*, *Koeleria nitida*, *Poa fendleriana*, and *Sitanion hystrix*.

Forb cover is more diverse compared to other grass-dominated ponderosa pine habitat types. Species may include *Hieraceum fendleri*, *Lithospermum multiflorum*, *Lotus wrightii*, *Penstemon* spp., and *Senecio neomexicanus*.

Physical setting.—This habitat type, based on a larger sample, has been described for northern Arizona (Hanks et al. 1983) and for the Gila National Forest[5]. In both studies, it was found between 8,000 and 8,700 feet (2,440 and 2,650 m) in elevation. It occurs on all aspects of varying slope.

Ecotones and adjacent habitats.—The one sample of this habitat type was found on a north-facing slope with *Picea pungens* stands in a nearby canyon, a typical location according to Fitzhugh et al.[5] The PIPO/FEAR HT and the PIPO/MUVI HT are common adjacent habitat types.

Discussion.—The PIPO/MUVI-FEAR HT is not common on the Cibola National Forest and is represented by only one plot in this study. However, this was clearly a PIPO/MUVI-FEAR HT according to descriptions from other areas where the type is more common (Hanks et al. 1983, Fitzhugh et al.[5]). The one area sampled may be descriptive of the QUGA phase of the habitat type identified by Hanks et al. (1983), but data are inconclusive and it is retained in the typic phase.

Pinus ponderosa/Muhlenbergia montana habitat type (PIPO/MUMO HT; ponderosa pine/mountain muhly)

Vegetation.—*Pinus ponderosa* is the dominant overstory species (fig. 19). *Pinus edulis* and *Juniperus deppeana* are present in the younger age classes, where they are nearly as abundant as *Pinus ponderosa*. Other conifer tree species are absent, but *Quercus gambelii* in tree form can be a minor component of the overstory.

Total shrub cover, which is dominated by the shrubby form of *Quercus gambelii*, rarely exceeds 5% in this habitat type. Other shrubs which may be present are *Berberis repens*, *Ceanothis fendleri*, and *Yucca baccata*.

Graminoids are the dominant undergrowth species and often exceed 15% cover. *Muhlenbergia montana* is constant and is dominant or codominant with other graminoids. Other common species include *Carex rossii*, *Koeleria nitida*, *Poa fendleriana*, and *Sitanion hystrix*.

Forbs are minor in this habitat type; common species include *Lotus wrightii*, *Penstemon* spp., and *Senecio neomexicanus*.

Physical setting.—The PIPO/MUMO HT is common on west-, south-, and east-facing slopes, and occasionally is found on north aspects. It occurs on lower to upper slopes of ridges between 7,500 and 8,500 feet (2,285 and 2,590 m). Exposure of bare rock and soil is common on these sites, each averaging about 10%.

Ecotones and adjacent habitats.—The PIPO/MUMO HT is often adjacent to the PIPO/FEAR HT. The transition is marked by the appearance of *Festuca arizonica*. Occasionally the PIPO/QUGA HT will be adjacent. At lower elevations, the transition may be directly to pinyon-juniper woodlands. Higher elevations often support the PSME/MUMO HT, where there is an increase in forb diversity.

Figure 19.—*Pinus ponderosa/Muhlenbergia montana* habitat type: Stinking Springs Canyon (8,150 feet or 2,485 m). *Pinus ponderosa* dominates the canopy. Shrub cover is low, with *Muhlenbergia montana* and *Poa fendleriana* dominating the grass cover.

Discussion.—The PIPO/MUMO HT is widespread in the Zuni Mountains and the Mount Taylor region. One stand of this habitat type was found in the Manzano Mountains, but others probably occur in the Sandia Mountains as well.

Grazing is widespread, and where pressure is intense, *Poa fendleriana* may increase in cover.

This habitat type occurs in northern New Mexico (DeVelice et al. 1986) and in the Gila National Forest[5]. It was not found in northern Arizona, but according to Fitzhugh et al.,[5] it may be represented by some plots in the PIPO/POFE community type described by Hanks et al. (1983).

Pinus ponderosa/Bouteloua gracilis habitat type (PIPO/BOGR HT; ponderosa pine/blue grama)

Vegetation.—*Pinus ponderosa* is the dominant timber species in all size classes (fig. 20). *Pinus edulis* is present, but usually as scattered individuals in the younger age classes. *Juniperus deppeana* is common, but not as consistent as *Pinus edulis*. *Quercus gambelii* can occur in tree form. *Juniperus deppeana*, *Pinus edulis*, and *Q. gambelii* are minor climax species.

Quercus gambelii is the only shrub that consistently occurs on these sites. Cover values may reach 10%.

Graminoids dominate the undergrowth of this habitat type. *Bouteloua gracilis* is constant and dominates mature sites. Cover values range from 5% to over 30%. *Koeleria nitida*, *Muhlenbergia montana*, *Poa fendleriana*, and *Sitanion hystrix* are common and abundant. Species of *Stipa* occasionally are present. Average grass cover for the sample plots was over 30%.

Forbs are minor in occurrence. Common species include *Artemisia ludoviciana, Erigeron flagellaris, Lotus wrightii, Penstemon* spp., and *Senecio neomexicanus.*

Physical setting.—The PIPO/BOGR HT can be found throughout the Cibola National Forest in isolated stands on ridges. It may be found on all aspects at elevations ranging from 7,500 to 8,500 feet (2,285 to 2,590 m). In the upper elevation range of the habitat type, it occurs on warmer aspects—west and southwest.

Ecotones and adjacent habitats.—At higher elevations, the type may be adjacent to an ABCO series habitat type, commonly the ABCO/QUGA HT. Within ponderosa pine forests, the PIPO/BOGR HT often forms mosaics with the PIPO/MUMO HT or occasionally occurs as patches within the PIPO/QUGA HT.

Discussion.—The PIPO/BOGR HT was previously described by Hanks et al. (1983), DeVelice et al. (1986), and Fitzhugh et al.[5] Factors leading to the creation of a suitable environment for the PIPO/BOGR HT are not clear. At higher elevations, its occurrence alongside the *Abies concolor* series may be an expression of warmer aspects. Also, soils and drainage may explain the shift from shrub-dominated stands—PIPO/QUGA HT or ABCO/QUGA HT—to the grass-dominated PIPO/BOGR HT.

Because of the heavy grass cover in this type, it may be subjected to intense grazing, which tends to increase the density of *Bouteloua gracilis, Poa fendleriana,* and many forb species. Overgrazing may decrease grass cover, expose more soil, and increase disturbance indicator species such as *Artemisia* spp. and *Hymenoxys* spp.

The PIPO/BOGR HT appears to be common in southwestern forests according to Hanks et al. (1983), DeVelice et al. (1986), and Fitzhugh et al.[5] The PIPO/BOGR HT on the Cibola National Forest may be identical to the *Quercus gambelii* phase described by the above authors. However, the plots in this study were not as xeric as those described elsewhere and data were inadequate. Hence, it was identified as the typic phase.

Figure 20.—*Pinus ponderosa/Bouteloua gracilis* habitat type: west slope Sandia Escarpment (8,220 feet or 2,505 m). *Pinus ponderosa* is dominant but sparse. *Quercus gambelii* sometimes has relatively high coverage values in the shrub layer. *Bouteloua gracilis* dominates the grass layer.

Pinus ponderosa/Cinder soils habitat type (PIPO/Cinder HT; ponderosa pine/cinder soils)

Vegetation.—*Pinus ponderosa,* the major timber species, is represented by scattered mature individuals and few trees in the regeneration class (fig. 21). *Pinus edulis* is present, but with fewer individuals than *P. ponderosa. Juniperus scopulorum* may be present, but it is not abundant. The average basal area measured was 45 square feet per acre (10.3 m^2/ha).

Although *Ribes cereum* frequently is present in stands represented by the PIPO/Cinder HT, it was not found in sampled plots of this study. Other shrubs occasionally include *Holodiscus dumosus* and *Quercus gambelii.* The undergrowth is dominated by graminoids, which appear in patchy clumps throughout the stand. *Muhlenbergia montana* is prominent and has coverage values over 10%. Other consistent species include *Poa fendleriana, Schizachyrium scoparium,* and *Sitanion hystrix. Bouteloua gracilis, Carex rossii,* and *Koeleria nitida* are less consistent, but common. Forbs are diverse but account for less than 5% cover; *Bahia dissecta, Cryptantha jamesii, Ipomopsis aggregata, Lithospermum multiflorum, Lotus wrightii, Lupinus* spp., and *Penstemon barbatus* are common.

Physical setting.—The diagnostic feature of this habitat type is the basaltic cinder soil, which is characteristically porous in the upper horizon and is subject to slippage on steeper slopes. The droughty nature of these easily drained and unstable soils results in stands with open canopies and patchy grass cover. Sites occupied by the habitat type occur on all aspects from 7,700 to 8,500 feet (2,345 to 2,590 m).

Ecotones and adjacent habitats.—The PIPO/Cinder HT is an isolated habitat type. It is found only in the southeast Zuni Mountains in the cinder hills near Cerro Bandera and Twin Craters. The pinyon-juniper woodland occurs along the lower elevations of these cinder hills.

Discussion.—The PIPO/Cinder HT, although poorly rated for timber production, covers a large area in the Zuni Mountains. It is similar in vegetation composition to the PIPO/MUMO HT, but differs in overstory abundance, prominent soils, and diversity of forbs. Although only four plots were measured for this habitat type, the consistency of the data warrants a separate habitat type classification.

Soils of this habitat type are unstable and shift easily following disturbance. Successional relationships are unclear. However, shrub species such as *Fallugia paradoxa* and *Ribes cereum* may increase after disturbance to sites.

Hanks et al. (1983) found a ponderosa pine habitat type on cinder soils in northern Arizona, the *Pinus ponderosa/Bouteloua gracilis* habitat type *Andropogon hallii* phase, which showed a close affinity to other dry ponderosa pine types. The habitat type found in the Cibola National Forest differs from the phase in northern Arizona and from other *Pinus ponderosa* types. To emphasize its unusual characteristics, it is best described as a separate habitat type. More intensive sampling of cinder hill sites in the future may result in their reclassification into

geographically disjunct phases of one or more related habitat types.

Other Ponderosa Pine Habitat Types

Two additional habitat types were found on the Cibola National Forest, but data were inadequate to provide full type descriptions because of their limited nature. They were, however, distinctive enough to warrant recognition for further assessment and research.

The one sample plot of the *Pinus ponderosa*/Riparian habitat type (PIPO/Riparian HT) was found in the Zuni Mountains, near Sawyer Creek, at 8,290 feet (2,525 m) in elevation (fig. 22). It was located in a cool, moist drainage representative of the mesic portion of the ponderosa pine moisture gradient, but at the lower end of the elevation range of the species. The diagnostic feature of the habitat type appears to be species diversity. *Pinus ponderosa* is the dominant overstory species, and *Quercus gambelii* is the dominant shrub. Twenty-two species of forbs were identified on the one plot and included *Allium* spp., *Galium boreale*, *Iris missouriensis*, *Pseudostellaria jamesiana*, *Thalictrum fendleri*, and *Thermopsis pinetorum*. Graminoids also were diverse; 15 species were found. *Agropyron* spp., *Festuca arizonica*, *Juncus* spp., *Lycurus pheloides*, *Muhlenbergia longiligula*, *M. montana*, and *Poa pratensis* were abundant. Undergrowth cover for the site totaled over 40%.

The *Pinus ponderosa*/Rockland habitat type (PIPO/Rockland HT) previously described by Fitzhugh et al.[5] also was found in the Zuni Mountains on the southwestern slope of Oso Ridge at 8,100 feet (2,470 m) (fig. 23). This habitat type is characterized by very little soil or litter and represents the dry end of the moisture gradient. The small amount of vegetation is sparse and grows in pockets of accumulated soil in cracks and depressions of exposed bedrock. These conditions may suggest early successional responses to disturbance, but the age of the overstory (200+ years) indicates the relative stability of the stands. Technically, such stands can be considered an edaphic climax. Mature *Pinus ponderosa* forms a sparse and open canopy. Although coverage by undergrowth species is low, diversity is fairly high. The plot contained 17 forb and 10 graminoid species. *Quercus gambelii* was present in trace amounts. Graminoids included *Aristida arizonica*, *Blepharoneuron tricholepis*, *Bouteloua gracilis*, *Muhlenbergia virescens*, and *Poa fendleriana*. Bare rock exposure was over 70% on this plot. Rockland habitat types, although not widespread, probably are more common than indicated by the one plot.

Figure 21.—*Pinus ponderosa*/Cinder soils habitat type: Cinder Hills, Zuni Mountains (7,940 feet or 2,420 m). *Pinus ponderosa* is the dominant overstory species, with scattered *Pinus edulis*. The shrub layer is minimal, but *Holodiscus dumosus* and *Ribes* species can be found. *Muhlenbergia montana* and *Poa fendleriana* are the dominant grasses, while forbs are scattered and of minor coverage.

Figure 22.—*Pinus ponderosa*/Riparian habitat type: Sawyer Creek (8,290 feet or 2,525 m). *Pinus ponderosa* is the dominant overstory species, with *Quercus gambelii* the dominant shrub. Forb diversity is high, but no species is indicative of the type. Common grasses may include *Festuca arizonica* and *Muhlenbergia montana*.

Figure 23.—*Pinus ponderosa*/Rockland habitat type: Little Water Canyon (8,100 feet or 2,470 m). *Pinus ponderosa* dominates, and *Juniperus deppeana* is scattered. Forbs and grasses are diverse, but with low coverage values. Bare rock dominates plot surfaces.

SUMMARY AND CONCLUSIONS

Twenty-one forest habitat types were identified in this study of the northern portion of the Cibola National

Forest; additionally some types were separated into phases. The habitat types represent six forest series: *Abies concolor*, *Abies lasiocarpa*, *Picea engelmannii*, *Picea pungens*, *Pinus ponderosa*, and *Pseudotsuga menziesii*.

The *Picea engelmannii* series is represented by one habitat type, the PIEN/MOSS HT. Its occurrence on the Cibola National Forest is probably limited to the upper slopes of Mount Taylor. Successional forms of this type should be studied further, because drastic shifts in vegetational composition and site modification are suspected after disturbances. The successional role of *Pseudotsuga menziesii* and *Abies concolor* also should be investigated, especially in regard to the establishment of an overstory canopy under which spruce and fir can regenerate.

The *Abies lasiocarpa* series is represented by three habitat types: ABLA/VAMY, ABLA/ACGL, and ABLA/EREX. The undergrowth in the ABLA/VAMY HT and ABLA/ACGL HT is more shrub dominated than that of the ABLA/EREX HT in which forbs abound. The ABLA/EREX HT is found on Mount Taylor and in the Sandia Mountains; the ABLA/VAMY HT was sampled only on Mount Taylor and the ABLA/ACGL HT only in the Sandia Mountains. Both the *Picea engelmannii* and the *Abies lasiocarpa* series are important watershed forests, because a deep snow pack is retained into the warmer spring season.

The *Picea pungens* series is represented by the PIPU/CAFO and the PIPU/COST HT. The basic difference between these two types is shrub dominance in the PIPU/COST HT and graminoid and forb dominance in the PIPU/CAFO HT. Stands of *Picea pungens* habitat types are few and geographically isolated in the Southwest. These blue spruce forests on the Cibola National Forest are relatively inaccessible and are, therefore, not as disturbed as those found elsewhere. They provide forest diversity associated with abrupt environmental changes from warmer forests on adjacent slopes to canyon-bottom forests that are cooler, more moist, and exhibit greater herbaceous production. Such an environmental edge is a critical aspect of wildlife management (Thomas 1979). The *Picea pungens* habitat types also are important for maintaining streamside integrity, and should be studied further for their response to disturbance.

The two habitat types in the *Abies concolor* series, ABCO/ACGL and ABCO/QUGA, illustrate the less diverse characteristics of the series in the Cibola National Forest than are found in other New Mexico forests (Alexander et al. 1984a, DeVelice et al. 1986, Fitzhugh et al.[5]). The series is more common in the Sandia and Manzano Mountains than on Mount Taylor and in the Zuni Mountains. This may be a result of steep topographical situations and subsequent abrupt environmental changes between the pinyon-juniper woodlands and the cool, moist *Abies concolor* forests in the Sandia and Manzano Mountains. Concurrently, the steep topography reduces the extent of intermediate series—*Pseudotsuga menziesii* and *Pinus ponderosa*. Both habitat types of the *Abies concolor* series are shrub dominated, in contrast to habitat types of lower elevation series which support grass dominated undergrowths.

The *Pseudotsuga menziesii* series is most common in the Zuni Mountains. The two major habitat types of this series, the PSME/FEAR and PSME/MUMO, offer productive timber and grazing potentials. Successional forests of these habitat types should be studied regarding their response to prescribed fires. Under frequent but light fires, succession tends to maintain a *Pinus ponderosa* overstory with increased forb and grass cover. The less common PSME/BRCI HT, however, exhibits abundant grass cover in older stands with little disturbance. The PSME/QUGA HT has a limited distribution on the Cibola National Forest, occurring on low elevation, canyon side slopes. When found on cooler north and east aspects, it provides an overall environmental diversity of a cool, moist forest surrounded by warmer *Pinus ponderosa* forests. Timber productivity is low in the PSME/QUGA HT and successional patterns are not well understood.

The *Pinus ponderosa* series is most abundant in the Zuni Mountains and the Mount Taylor region, whereas its areal extent is limited near the Sandia and Manzano Mountains where *Abies concolor* and *Pseudotsuga menziesii* extend to the pinyon-juniper zone. The preponderance of grass-dominated habitat types is exemplified by six grass habitat types and only one shrub habitat type. The grass cover of the PIPO/QUGA HT increases at its lower elevation ranges. On many sites, competition between oak brush and timber species was apparent, particularly in younger successional stands that originated from intense fires. The grass-dominated habitat types provide grazing, which—with proper intensity and season of use—will maintain desired communities. Overgrazing results in shifts to less palatable species and eventual dominance by invader species. The ponderosa pine forest offers a wide range of sites for potential timber production. Higher growth rates will be found in the PIPO/FEAR HT; lower rates will prevail in the cinder and rockland habitat types of the Zuni Mountains.

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APPENDIXES

Appendix A. Keys to the Climax Forest Series and Habitat Types of the Northern Portion of the Cibola National Forest

The first step in using keys in habitat type classification is to determine the series level of a particular stand by identifying climax overstory tree species. A climax species is well represented in the overstory of older stands that are in equilibrium with the environment, and also is reproducing in the understory. In contrast, the climax species in younger stands may be reproducing under a canopy even though mature individuals of the species are not present in the overstory. Field investigators must judge whether such reproduction will grow to maturity to become the climax dominant, replacing the existing overstory of seral species. This determination is especially difficult in mixed conifer forests where any of several associated species, other than the climax tree species, may dominate the overstory.

Futhermore, diagnostic species may not always be present in a particular seral stand because of disturbance or the lack of a seed source. The investigator must compare the stand with the habitat type descriptions in order to correctly identify the habitat type. When choices in the keys are not clear because of stand conditions, descriptions and tables should be used to distinguish between types.

A1. Key to Climax Forest Series

1. PIEN or ABLA present in overstory; regeneration sufficient to confirm their status as climax dominants; PIPU rare, usually absent. PIEN and ABLA series. ---------- Key A2
1. PIEN and ABLA absent or accidental, or if present, then PIPU also prominent. ---------- 2
   2. PIPU present in overstory and/or as reproduction. PIPU series. ---------- Key A3
   2. PIPU absent; ABCO, PSME, or PIPO present. ---------- 3
3. ABCO present in overstory, or prominent in understory; not accidental. Other species present but not as climax dominants. ABCO series. ---------- Key A3
3. ABCO absent or accidental, not a dominant component of overstory or understory. ---------- 5
   5. PSME clearly the dominant climax species; PIPO late successional; ABCO absent or accidental. PSME series. --- Key A4
   5. PSME not a strong component of either overstory or understory. PIPO the climax dominant. PIPO series. -------- Key A5

A2. Key to *Picea engelmannii* and *Abies lasiocarpa* Series Habitat Types

1. Undergrowth nearly absent; litter layer thick; moss often abundant; PIEN the dominant overstory species; ABLA a minor overstory component. ---------- PIEN/MOSS HT
1. Undergrowth abundant; ABLA a prominent component of the climax stand. ---------- 2
   2. Forbs dominate the undergrowth; *Erigeron eximius* present, sometimes the major forb. ---------- ABLA/EREX HT
   2. Shrubs usually dominate the undergrowth; *Bromus ciliatus* the dominant grass; *Erigeron eximius* sometimes present, but always subordinate to the shrubs. ---------- 3
3. *Acer glabrum* the prominant shrub, often forming part of the canopy; *Bromus ciliatus* abundant in the undergrowth; *Pseudotsuga menziesii* and *Abies concolor* often present in late successional stands. ---------- ABLA/ACGL HT
3. *Acer glabrum* absent; *Vaccinium myrtillus* the abundant shrub in the undergrowth. ---------- ABLA/VAMY HT

A3. Key to *Picea pungens* and *Abies concolor* Series Habitat Types.

1. *Picea pungens* abundant in overstory; canyon sites; *Abies concolor* seral or absent. ---------- 2
1. *Picea pungens* absent; *Abies concolor* dominant in overstory. ---------- 3
   2. Graminoids and forbs dominate undergrowth; *Carex foenea* dominant; *Fragaria ovalis* common. --------- PIPU/CAFO HT
   2. Shrubs, particularly *Cornus stolonifera*, the dominant feature of undergrowth; sites often found on streamside benches. ---------- PIPU/COST HT
3. *Acer glabrum* present, usually the dominant tall shrub; *Quercus gambelii* present, but usually subordinate to *Acer glabrum*. ---------- ABCO/ACGL HT
   3a. *Berberis repens* absent or in trace amounts; *Pseudotsuga menziesii* present, often abundant. -------- ACGL typic phase
   3b. *Berberis repens* present in greater than trace amounts. ---------- BERE phase
   3c. Sites in cool, wet drainages; coniferous species other than *Abies concolor* absent. ---------- RIPARIAN phase
3. *Acer glabrum* absent; *Quercus gambelii* usually the dominant tall shrub. ---------- ABCO/QUGA HT

A4. Key to *Pseudotsuga menziesii* Series Habitat Types

1. Shrubs abundant with over 5% cover; *Acer glabrum* or *Quercus gambelii* the dominant species; *Bromus ciliatus* abundant in association with *Acer glabrum*. ---------- 2
1. Shrubs may be present, but usually less than 5% cover; if shrubs abundant, then with less cover than either *Festuca arizonica* or *Muhlenbergia montana*. ---------- 3
   2. *Acer glabrum* an abundant tall shrub; *Bromus ciliatus* often with more than 30% cover; *Quercus gambelii* minor, usually absent. ---------- PSME/BRCI HT
   2. *Acer glabrum* absent; *Bromus ciliatus* often present but rarely over 5% cover; *Quercus gambelii* the dominant tall shrub. ---------- PSME/QUGA HT
3. *Festuca arizonica* the dominant graminoid; *Muhlenbergia montana* usually present, but always in association with *F. arizonica*. ---------- PSME/FEAR HT
3. *Festuca arizonica* absent; *Muhlenbergia montana* abundant, usually dominating graminoids; *Poa fendleriana* also abundant, at times dominant. ---------- PSME/MUMO HT

A5. Key to *Pinus ponderosa* Series Habitat Types

1. Site characterized by bare rock covering much of surface. Soil less than 4 inches (10 cm) deep. -------- PIPO/ROCKLAND HT
1. Sites not characterized by bare rock and shallow soils over bedrock. ---------- 2
   2. Sites of cinder hills, upper soil composed of loose, unstructured cobbly volcanic cinder; *Muhlenbergia montana* usually the prominent graminoid. ---------- PIPO/CINDER HT
   2. Soils not composed of cinders on cinder hill sites. ---------- 3
3. Shrubs the dominant component of undergrowth; *Quercus gambelii* present with more than 5% cover, or if less than 5% cover, then shrubs dominant over graminoids and forbs. ---------- PIPO/QUGA HT
   3a. *Pinus edulis* rare, not abundant in canopy; *Schizachyrium scoparium* absent. ---------- QUGA typic phase
   3b. *Pinus edulis* sometimes abundant, definite component of overstory or abundant as regeneration; *Schizachyrium scoparium* usually absent or present only with trace amounts of cover ---------- PIED phase
   3c. *Schizachyrium scoparium* present with 1% cover or more. *Pinus edulis* often present. ---------- SCSC phase
3. Graminoids dominate undergrowth; *Quercus gambelii* may be abundant, but graminoid cover exceeds that of *Q. gambelii*. -- 4
   4. *Schizachyrium scoparium* a prominent graminoid, having more than 1% cover. *Quercus gambelii* present with more than 5% cover. ---------- PIPO/QUGA HT, SCSC phase
   4. Other grasses dominant. *Schizachyrum scoparium* with 1% or less cover. *Quercus gambelii* present or absent. -------- 5
5. *Festuca arizonica* or *Muhlenbergia montana* the dominant graminoid; *Muhlenbergia virescens* absent. ---------- 6
5. *Festuca arizonica* absent, or if present, codominant with *Muhlenbergia virescens*. ---------- 7
   6. Wet riparian sites with *Festuca arizonica* and *Muhlenbergia montana* sharing dominance. ---------- PIPO/Riparian HT
   6. *Festuca arizonica* usually dominant, upland sites. ---------- PIPO/FEAR HT
      6a. *Quercus gambelii* less than 5% cover; *Bouteloua gracilis* absent. ---------- FEAR typic phase
      6b. *Quercus gambelii* with more than 5% cover; *Festuca arizonica* with greater cover than *Q. gambelii*. ---- QUGA phase
      6c. *Bouteloua gracilis* present in greater than trace amounts; *Quercus gambelii* less than 5% cover. ------ BOGR phase
7. *Muhlenbergia virescens* present, often the dominant graminoid species; *Festuca arizonica* may be present as codominant. -- 8
7. *Muhlenbergia virescens* absent; other graminoids may be abundant. ---------- 9
   8. *Festuca arizonica* absent; *Muhlenbergia virescens* dominant graminoid. ---------- PIPO/MUVI HT
   8. *Muhlenbergia virescens* codominant with *Festuca arizonica*, both graminoids obviously more abundant than other species. ---------- PIPO/MUVI-FEAR HT
9. *Muhlenbergia montana* abundant, usually dominant; *Poa fendleriana* also abundant, sometimes exceeding *M. montana; Bouteloua gracilis* rare, usually absent. ---------- PIPO/MUMO HT
9. *Bouteloua gracilis* the dominant grass, usually over 5% cover; *Stipa* species may be abundant. ---------- PIPO/BOGR HT

Appendix B. Plant Species Identified in Study[1]

Trees

Abies concolor
Abies lasiocarpa
Acer negundo
Juniperus deppeana
Juniperus monosperma
Juniperus osteosperma
(*J. utahensis*)
Juniperus scopulorum
Picea engelmannii
Picea pungens
Pinus edulis
Pinus ponderosa
Pinus strobiformis[2]
Populus tremuloides
Pseudotsuga menziesii
Quercus arizonica
Quercus gambelii
Quercus grisea

Shrubs

Acer glabrum
Alnus oblongifolia
Alnus tenuifolia
Amelanchier utahensis
Berberis repens
(*Mahonia repens*)
Ceanothus fendleri
Ceanothus integerrimus
Cercocarpus montanus
(*C. betuloides*)
Chrysothamnus spp.
Chrysothamnus depressus
Chrysothamnus nauseosus
Chrysothamnus viscidiflorus
Cornus stolonifera
(*Swida sericea*)
Fallugia paradoxa
Fendlera rupicola
Garrya wrightii
Gutierrezia sarothrae
(*Xanthocephalum sarothrae*)
Holodiscus dumosus
Hymenoxys acaulis
Hymenoxys richardsonii
Jamesia americana
Juniperus communis
Lonicera spp.
Lonicera arizonica
Lonicera involucrata
Lonicera utahensis
Lycium spp.
Pachistima myrsinites
Physocarpus monogynus
(*P. malvaceous*)
Potentilla fruticosa
(*Pentaphylloides floribunda*)
Prunus virginiana
Purshia tridentata
Quercus undulata
(*Q. gambelii* × *Q. grisea*)
Rhus trilobata
(*R. aromatica*)
Ribes spp.
Ribes cereum
Ribes leptanthum
Robinia neomexicana
Rosa spp.
Rosa woodsii
Rubus neomexicanus
Rubus parviflorus

Shrubs continued

Rubus strigosus
(*R. idaeus*)
Salix spp.
Salix scouleriana
Sambucus neomexicanus
Symphoricarpos oreophilus
Tetradymia canescens
Toxicodendron rydbergii
(*T.* (*Rhus*) *radicans*)
Vaccinium myrtillus
(*V. oreophilum*)
Vitis arizonica
Yucca angustissima
Yucca baccata
Yucca schotti

Graminoids

Agropyron smithii
Agropyron trachycaulum
Agrostis scabra
Agrostis semiverticillata
Andropogon gerardi
Aristida arizonica
Aristida fendleriana
Blepharoneuron tricholepis
Bouteloua curtipendula
Bouteloua gracilis
Bromus spp.
Bromus carinatus
Bromus ciliatus
(*B. richardsonii*)
(*Bromopsis ciliata*)
Bromus frondosus
(*Bromopsis frondosa*)
Bromus marginatus
(*Ceratochloa marginata*)
Bromus tectorum
Calamagrostis canadensis
Calamagrostis inexpansa
(*C. neglecta*)
Carex spp.
Carex aurea
Carex foenea
Carex geophila
Carex media
(*C. norvegica*)
Carex occidentalis
Carex rossii
Carex scoparia
Carex vallicola
Cyperus spp.
Dactylis glomerata
Danthonia californica
Danthonia intermedia
Danthonia parryi
Deschampsia caespitosa
Elymus glaucus
Elymus triticoides
Festuca arizonica
Festuca octoflora
Festuca sororia
Festuca thurberi
Glyceria striata
Juncus spp.
Juncus balticus
(*J. arcticus*)
Juncus interior
(*J. tenuis*)
Juncus saximontanus

Graminoids continued

Koeleria nitida
(*K. cristata*)
(*K. macrantha*)
(*K. pyramidata*)
Lycurus phleoides
Melica porteri
Muhlenbergia spp.
Muhlenbergia emersleyi
Muhlenbergia longiligula
Muhlenbergia montana
Muhlenbergia virescens
Oryzopsis micrantha
Panicum bulbosum
Piptochaetium fimbriatum
Poa compressa
Poa fendleriana
Poa nervosa
(*P. traceyi*)
(*P. wheeleri*)
Poa palustris
Poa pratensis
Schizachyrium scoparium
(*Andropogon scoparius*)
Setaria spp.
Sitanion hystrix
(*S. longifolium*)
Stipa spp.
Stipa comata
Stipa lettermani
Stipa pringlei
Trisetum montanum
(*T. spicatum*)

Forbs

Achillea millefolium
(*A. lanulosa*)
Actaea rubra spp. *arguta*
(*A. arguta*)
Agastache pallidiflora
Ageratina herbacea
(*Eupatorium herbaceum*)
Agoseris spp.
Agoseris aurantiaca
Agoseris glauca
Allium spp.
Allium cernuum
Allium geyeri
Androsace occidentalis
Antennaria spp.
Antennaria marginata
(*A. neglecta*)
Antennaria parvifolia
(*A. aprica*)
Anthericum torreyi
Apocynum cannabinum
Aquilegia chrysantha
Aquilegia elegantula
Arabis fendleri
Arabis pendulina
Aralia racemosa
Arenaria spp.
Arenaria eastwoodiana
Arenaria fendleri
Arenaria lanuginosa
(*A. confusa*)
(*A. saxosa*)
Artemisia spp.
Artemisia campestris
(*A. pacifica*)
Artemisia carruthii

Forbs continued

Artemisia dracunculus
(*A. dracunculoides*)
Artemisia franserioides
Artemisia frigida
Artemisia ludoviciana
Asclepias asperula
(*A. capricornu*)
Aster spp.
Aster foliaceus
Astragalus spp.
Astragalus amprioxys
Astragalus egglestonii[3]
(*A. rusbyi*)
Astragalus humistratus
Astragalus mollisimus
Astragalus recurvus
Bahia dissecta
Besseya plantaginea
Brickellia californica
Brickellia grandiflora
Calliandra humilis
Calochortus spp.
Calochortus gunnisoni
Campanula rotundifolia
Castilleja spp.
Castilleja austromontana
Castilleja integra
Castilleja linariaefolia
Chaptalia alsophila
Chenopodium aff. album
Cirsium spp.
Cirsium calcareum
(*C. pulchellum*)
Cirsium grahami
Cirsium parryi
Cirsium wheeleri
Clematis ligusticifolia
Clematis pseudoalpina
(*C. columbiana*)
Corallorhiza spp.
Corallorhiza maculata
Cryptantha spp.
Cryptantha jamesii
Cystopteris fragilis
Delphinium spp.
Draba spp.
Draba helleriana
Drymaria tenella
Dugaldia hoopesii
(*Helenium hoopesii*)
Echinocereus spp.
(*Mammillaria* spp.)
Epilobium paniculatum
Equisetum spp.
Equisetum arvense
Equisetum hiemale
(*E. hyemale*)
(*Hippochaete hyemalis*)
Erigeron spp.
Erigeron eximius
(*E. superbus*)
Erigeron flagellaris
Erigeron formosissimus
Erigeron speciosus
(*E. macranthus*)
Erigeron platyphyllus
Eriogonum alatum
Eriogonum jamesii
Eriogonum racemosum
Erysimum capitatum

Forbs continued

Euphorbia spp.
Euphorbia lurida
Fragaria americana
(*F. bracteata*)
(*F. vesca*)
Fragaria ovalis
(*F. virginiana*)
Franseria spp.
Galium spp.
Galium boreale
Galium microphyllum
Galium triflorum
Galium wrightii
Geranium spp.
Geranium caespitosum
(*G. fremontii*)
Geranium richardsonii
Gilia spp.
Goodyera oblongifolia
Gutierrezia spp.
Habenaria spp.
(*Limnorchis* spp.)
Habenaria sparsiflora
Hackelia floribunda
Haplopappus parryi
(*Oreochrysum parryi*)
(*Solidago parryi*)
Hedeoma drummondii
Hedeoma oblongifolium
Hedyotis pygmaea
(*Houstonia wrightii*)
Helianthella parryi
Helianthella quinquenervis
Helianthus spp.
Heterotheca fulcrata
(*H. villosa*)
(*Chrysopsis fulcrata*)
(*C. villosa*)
Heterotheca grandiflora
Heuchera parvifolia
Hieracium fendleri
Hymenopappus filifolius
(*H. lugens*)
Hymenopappus mexicanus
Hymenoxys spp.
Hymenoxys acaulis
Hymenoxys bigelovii
Hymenoxys brandegi
Hymenoxys cooperi
Hymenoxys ivesiana
Ipomoea spp.
Ipomopsis aggregata
(*Gilia aggregata*)
Iris missouriensis
Kochia spp.

Forbs continued

Lactuca spp.
Lactuca serriola
(*L. scariola*)
Lappula redowskii
Lathyrus arizonicus
Lathyrus graminifolius
Lathyrus leucanthus
(*L. lanzwertii*)
Lesquerela fendleri
Leucelene ericoides
(*Aster arenosus*)
(*A. hirtifolius*)
Ligusticum porteri
Linanthus spp.
(*Linanthastrum* spp.)
Lithospermum multiflorum
Lotus spp.
Lotus utahensis
Lotus wrightii
Lupinus spp.
Lupinus argenteus
Lupinus kingii
Malaxis soulei
(*M. macrostachya*)
Mammillaria spp.
(*Coryphantha* spp. in part)
Melilotus albus
Melilotus officinalis
Mertensia ciliatus
Mertensia franciscana
Mirabilis oxybaphoides
Myosotis scorpiodes
Oenothera spp.
Oenothera rosea
Opuntia spp.
Orobanche ludoviciana
Orobanche multiflora
Orthocarpus purpureo-albus
Osmorhiza chilensis
Osmorhiza depauperata
(*O. obtusa*)
Oxalis metcalfei
(*O. alpina*)
Oxybaphus linearis
(*Mirabilis linearis*)
Oxytropis lambertii
Pedicularis spp.
Pedicularis centranthera
Pedicularis grayi
Pellea atropurpurea
Penstemon spp.
Penstemon barbatus
Penstemon bridgesii
Penstemon eatoni

Forbs continued

Penstemon linarioides
Penstemon strictus
Penstemon virgatus
(*P. putus*)
Penstemon whippleanus
Petalostemum spp.
Petalostemum canidum
(*Dalea candida*)
(*D. oligophylla*)
Phacelia spp.
Phlox spp.
Phlox speciosa
Plantago spp.
Polemonium foliosissimum
Polygala alba
Polygonum sawatchense
Potentilla spp.
Potentilla concinna
Potentilla crinita
Potentilla fruticosa
Potentilla hippiana
Pseudocymopteris montanus
Pseudostellaria jamesiana
(*Stellaria jamesiana*)
Psoralea tenuiflora
Pteridium aquilinum
Pyrola spp.
Ramischia secunda
(*Pyrola secunda*)
(*Orthilia secunda*)
Ranunculus inamoenus
Rudbeckia laciniata
Scrophularia parviflora
Sedum spp.
Senecio spp.
(*Packera* spp.)
Senecio actinella
Senecio bigelovii
(*Ligularia bigelovii*)
Senecio eremophilus
Senecio hartianus
Senecio neomexicanus
Senecio multilobatus
Senecio sacramentanus
Senecio sanguisorboides
Senecio wootonii
Silene laciniata
Silene scouleri
Sisymbrium spp.
(*Thelypodiopsis* spp. in part)
Sisymbrium altissimum
Sisymbrium irio
Sisymbrium linearifolium
(*Thelypodiopsis linearifolia*)

Forbs continued

Sisyrinchium demissum
(*S. angustifolium*)
Smilacina racemosa
Smilacina stellata
Solidago spp.
Solidago sparsiflora
Solidago wrightii
Sphaeralcea grossulariaefolia
Stellaria spp.
Stellaria longifolia
Stellaria umbellata
Streptanthus spp.
Swertia radiata
(*Frasera speciosa*)
Talinum spp.
Taraxacum spp.
Taraxacum laevigatum
Taraxacum officinale
Thalictrum fendleri
Thelesperma megapotamicum
Thermopsis pinetorum
(*T. divaricarpa*)
(*T. rhombifolia*)
Thlaspi spp.
Thlaspi arvense
Thlaspi montanum
(*T. alpestre*)
(*T. fendleri*)
Townsendia exscapa
Tragia stylaris
(*T. ramosa*)
Tragopogon dubius
Trifolium spp.
Trifolium rusbyi
Trifolium subcaulenscens
Urtica gracilis
Valeriana spp.
Valeriana capitata
(*V. capitata* ssp. *acutiloba*)
(*V. arizonica*)
Valeriana edulis
Verbascum thapsus
Verbena macdougalii
Verbena wrightii
Veronica spp.
Vicia spp.
Vicia americana
Vicia pulchella
Viguiera multiflora
(*Heliomeris multiflora*)
Viola spp.
Viola canadensis
Zigadenus elegans
(*Anticlea elegans*)

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[1]*Taxonomic authorities were Lehr (1978), Lehr and Pinkava (1980, 1982), Martin and Hutchins (1980, 1981), and Weber and Johnston (1979).*
[2]*A distinction was not made between* Pinus strobiformis *and* P. flexilis *in this study; both species were listed as* P. strobiformis.
[3]Astragalus egglestonii *and* A. rusbyi *are two distinct species, but the names of each have been misapplied to the other species (USDA 1982a, 1982b).*

Appendix C. Successional Status of Major Tree Species Within Habitat Types
C = major climax species S = major seral species a = accidental
c = minor climax species s = minor seral species

HABITAT TYPES	Species										
	ABLA	PIEN	PIPU	POTR	ABCO	PSME	PIST	PIPO	QUGA	PIED	JUDE
PIEN/MOSS HT	c	C	.	S	.	s	.	.	.	.	.
ABLA/ACGL HT	C	c	.	S	S	S	.	.	.	.	.
ABLA/EREX HT	C	C	.	S	s	s	.	.	.	.	.
ABLA/VAMY HT	C	C	.	S	s	s	.	.	.	.	.
PIPU/CAFO HT	.	c	C	S	a	C	a	a	.	.	.
PIPU/COST HT	.	.	C	S	.	C	.	.	.	.	.
ABCO/ACGL HT											
ACGL typic P	.	.	.	S	C	C	c	c	.	.	.
Riparian P	.	.	.	S	C	.	.	.	.	.	.
BERE P	.	.	.	S	C	C	c	c	.	.	.
ABCO/QUGA HT											
ABCO/QUGA HT	.	.	.	.	C	S	c	S	C	.	.
PSME/BRCI HT	.	.	.	S	.	C	c	c	.	.	.
PSME/FEAR HT	.	.	.	S	a	C	a	S	.	.	.
PSME/MUMO HT	.	.	.	.	a	C	s	C	.	a	a
PSME/QUGA HT	.	.	.	.	.	C	.	s	C	.	.
PIPO/QUGA HT											
QUGA typic P	.	.	.	.	.	.	.	C	C	a	a
PIED P	.	.	.	.	.	.	.	C	C	c	c
SCSC P	.	.	.	.	.	.	.	C	C	c	c
PIPO FEAR HT											
FEAR typic P	.	.	.	.	.	.	.	C	c	c	c
BOGR P	.	.	.	.	.	c	.	.	C	a	c
QUGA P	.	.	.	.	a	a	.	C	C	c	c
PIPO/MUVI HT	.	.	.	.	.	.	.	C	a	c	c
PIPO/MUVI-FEAR HT	.	.	.	.	.	.	.	C	c	.	.
PIPO/MUMO HT		.	.	.	.	c	.	.	C	c	c
PIPO/BOGR HT	.	.	.	.	.	.	.	C	c	c	c
PIPO/Cinders HT	.	.	.	.	.	.	.	C	.	c	.
PIPO/Riparian HT	.	.	.	.	.	.	.	C	c	.	.
PIPO/Rockland HT	.	.	.	.	.	.	.	C	.	.	.

Spacies and size class	PIEN/ Moss[2] HT (N=2)	ABLA/ ACGL HT (N=3)	ABLA/ EREX HT (N=7)	ABLA/ VAMY HT (N=1)	PIPU/ CAFO HT (N=3)	PIPU/ COST HT (N=4)	ABCO/ACGL HT: ACGL typic P (N=3)	ABCO/ACGL HT: Riparian P (N=3)	ABCO/ACGL HT: BERE P (N=5)	ABCO/ QUGA HT (N=14)	PSME/ BRCI HT (N=2)	PSME/ FEAR HT (N=4)	PSEM/ MUMO HT (N=5)	PSME/ QUGA HT (N=2)	PIPO/QUGA HT: QUGA typic P (N=5)	PIPO/QUGA HT: PIED P (N=12)	PIPO/QUGA HT: SCSC P (N=5)	PIPO/FEAR HT: FEAR typic P (N=15)	PIPO/FEAR HT: BOGR P (N=2)	PIPO/FEAR HT: QUGA P (N=2)	PIPO/ MUVI HT (N=3)	PIPO/ MUVI-FEAR HT (N=1)	PIPO/ MUMO HT (N=11)	PIPO/ BOGR HT (N=4)	PIPO/ Cinders HT (N=4)	PIPO/ Riparian HT (N=1)	PIPO/ Rock-land HT (N=1)
Abies lasiocarpa																												
Yng regen	25/50	3/67	18/100	3/100	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Adv ragan	17/50	12/100	9/86	7/100	•	•	•	•	T/20	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Matura	3/50	4/100	3/86	3/100	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Picee engelmannii																												
Yng regan	3/50	•	20/57	37/100	•	•	•	•	•	•	T/50	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Adv regan	4/100	1/67	7/86	28/100	•	•	•	•	T/20	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Matura	11/100	1/33	8/100	9/100	•	•	•	•	T/20	•	T/50	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Picea pungens																												
Yng regen	•	•	•	•	6/100	1/50	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Adv ragan	•	•	•	•	10/67	7/100	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Matura	•	•	•	•	4/100	6/100	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Populus tremuloides																		T/7										
Yng ragan	7/50	8/33	3/43	•	11/67	10/100	2/33	1/33	1/40	T/7	T/50	T/25	•	•	•	•	•	T/7	•	•	•	•	•	•	•	•	•	•
Adv ragan	•	1/33	4/43	•	1/67	1/75	•	•	•	•	T/50	T/25	•	•	•	•	•	T/7	•	•	•	•	•	•	•	•	•	•
Matura	•	T/33	1/29	•	1/67	T/25	•	T/33	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Abies concolor																T/25												
Yng regen	•	•	•	•	•	•	6/67	8/100	9/100	26/100	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Adv regen	•	2/33	T/14	•	•	•	9/100	10/100	15/100	33/100	•	•	•	•	•	•	•	•	•	•	•	•	•	•	T/25	•	•	•
Mature	•	1/33	T/14	•	•	•	6/100	5/100	7/80	3/79	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Pseudotsuga menziesii																												
Yng regen	•	T/33	T/14	•	12/67	5/75	4/100	•	1/60	2/64	36/100	23/100	40/100	17/100	T/20	T/17	•	T/7	•	•	•	•	T/9	•	•	•	•	•
Adv ragan	•	3/100	6/29	•	7/67	2/75	5/100	•	1/80	2/64	16/100	3/100	15/80	7/100	T/40	T/17	•	•	•	•	•	•	T/9	•	•	•	•	•
Matura	•	6/100	1/43	•	T/33	2/75	3/100	•	3/100	T/29	11/100	4/100	2/100	7/100	T/20	T/25	•	•	•	•	•	•	T/9	1/25	•	•	•	•
Pinus strobiformis									1/20	•	3/50	•	2/60	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Yng regan	•	•	•	•	•	•	•	•	T/20	•	•	T/25	3/60	•	•	T/8	•	T/7	•	•	•	•	•	•	•	•	•	•
Adv ragan	•	•	•	•	•	•	T/33	•	T/20	T/7	•	•	T/40	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Matura	•	•	•	•	•	•	T/33	•	T/20																			
Pinus ponderosa																												
Yng ragan	•	•	•	•	T/33	•	•	•	T/20	T/29	1/50	2/50	2/60	•	20/100	1/58	11/100	8/80	•	9/100	2/100	3/100	4/45	5/75	4/75	3/100	5/100	
Adv ragan	•	•	•	•	T/33	•	•	•	•	3/50	T/50	5/50	5/60	•	14/100	7/67	10/80	3/87	3/50	5/100	1/67	6/100	5/64	T/75	1/50	6/100	1/100	
Matura	•	•	•	•	T/33	•	•	•	T/20	2/71	•	3/100	2/80	•	6/100	5/100	3/100	6/100	5/100	5/100	3/100	13/100	6/100	6/100	2/75	2/100	2/100	
Pinus edulis																												
Yng ragan	•	•	•	•	•	•	•	•	T/20	3/36	•	•	1/40	2/50	•	17/92	9/60	9/40	9/100	•	6/100	•	1/45	3/100	3/75	•	•	
Adv regan	•	•	•	•	•	•	•	•	•	T/14	•	•	•	•	•	6/83	T/40	T/13	3/100	•	•	•	T/36	T/50	T/50	•	•	
Matura	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	T/8	T/20	•	1/50	•	•	•	•	•	•	•	•	
Juniperus deppeane																												
Yng ragen	•	•	•	•	•	•	•	•	•	•	•	•	•	•	10/20	T/25	T/20	T/27	•	T/50	T/33	•	1/55	T/25	•	•	1/100	
Adv regen	•	•	•	•	•	•	•	•	•	T/7	•	•	•	•	T/20	T/8	T/20	T/7	•	•	T/33	•	T/45	1/50	•	•	•	
Mature	•	•	•	•	•	•	•	•	•	T/7	•	•	T/20	•	T/20	T/17	T/20	•	•	•	T/33	•	T/27	•	•	•	1/100	
Juniperus osteosperme																												
Yng regan	•	•	•	•	•	•	•	•	T/20	T/14	•	•	•	•	T/20	T/8	1/20	•	•	•	•	•	•	•	•	•	•	
Adv ragan	•	•	•	•	•	T/25	•	•	T/20	•	•	•	•	•	•	T/8	•	T/7	•	•	•	•	T/9	T/25	•	•	•	
Mature	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	T/20	•	•	•	•	•	•	•	•	•	•	
Juniperus scopulorum																												
Yng regen	•	•	•	•	•	T/25	•	T/33	•	4/43	•	•	•	3/50	1/40	4/25	•	T/7	1/50	•	•	•	•	•	T/25	•	•	
Adv regen	•	•	•	•	•	•	•	•	•	2/36	•	•	•	2/50	T/40	5/42	•	T/7	•	•	•	•	•	•	T/25	•	•	
Mature	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	T/17	•	•	•	•	•	•	•	•	•	•	•	

[1]*Occurrence of each species in each habitat type end phase is indicated by two values separated by a slash. The first indicates the mean density (number of stems per plot) for the tree species, averaged over all plots in the habitat type. The value to the right of the slash is the constancy for each species in the habitat type or phase; it is the percentage of the total number of plots in the group in which the species was found. In cases where a species had less than 1% cover, T is used to the left of the slash. A dot indicates that the species was not found in a group.*

[2]*Descriptions of habitet types with small sample size (N < 5) were derived as explained under Results and Discussion section.*

Appendix E. Average Cover and Constancy of Major Shrub and Herbaceous Species by Habitat and Phase[1]

Species	PIEN/ Moss[2] HT (N=2)	ABLA/ ACGL HT (N=3)	ABLA/ EREX HT (N=7)	ABLA/ VAMY HT (N=1)	PIPU/ CAFO HT (N=3)	PIPU/ COST HT (N=4)	ABCO/ACGL HT: ACGL typic P (N=3)	ABCO/ACGL HT: Riparian P (N=3)	ABCO/ACGL HT: BERE P (N=5)	ABCO/ OUGA HT (N=14)	PSME/ BRCI HT (N=2)	PSME/ FEAR HT (N=4)
Shrubs												
Acer glabrum	•	14/100	•	•	5/67	T/25	12/100	30/67	4/80	•	6/100	T/25
Acer negundo	•	•	•	•	•	•	•	•	•	•	•	•
Alnus tenuifolia	•	•	•	•	•	4/25	•	•	•	•	•	•
Amelanchier utahensis	•	•	•	•	T/33	•	•	•	•	•	•	•
Berberis repens	•	•	T/29	•	2/100	4/100	T/33	1/66	5/80	2/79	•	1/50
Ceanothus fendleri	•	•	•	•	•	•	•	•	T/20	•	•	•
Ceanothus integerrimus	•	•	•	•	•	•	•	•	•	•	•	•
Cercocerpus montanus	•	•	•	•	•	•	•	•	T/20	T/21	•	•
Cornus stolonifera	•	•	•	•	T/33	24/75	•	T/33	T/20	T/36	•	•
Fallugia paradoxa	•	•	•	•	•	•	•	•	•	•	•	•
Holodiscus dumosus	•	•	•	•	•	•	T/33	•	•	T/21	T/100	1/50
Jamesie americana	•	•	T/14	•	•	•	•	18/67	•	•	•	•
Lonicere involucrata	•	•	•	•	•	T/25	•	•	•	•	•	•
Pachistime myrsinites	•	•	•	•	•	2/100	•	T/33	1/40	•	•	•
Physocerpus monogynus	•	•	•	3/100	•	•	•	•	•	T/7	•	•
Prunus virginiena	•	T/33	•	•	T/33	2/50	T/67	T/33	T/40	T/14	•	•
Quercus gambelii	•	•	•	•	•	2/75	3/67	4/67	5/60	9/93	1/50	2/75
Quercus grisea	•	•	•	•	•	•	•	•	•	•	•	•
Quercus undulate	•	•	•	•	•	•	•	•	•	•	•	•
Ribes spp.	•	•	•	•	T/100	6/75	•	•	•	•	•	T/25
Robinie neomexicana	•	•	•	•	•	•	T/33	T/33	T/60	T/7	T/50	T/25
Rosa spp.	•	•	•	•	•	T/25	•	•	•	•	•	•
Rubus strigosus	•	•	•	•	•	•	•	•	•	•	•	•
Salix spp.	•	•	•	•	•	T/25	•	•	•	•	•	•
Symphoricerpos oreophilus	•	T/67	T/43	•	•	T/50	2/100	5/67	3/100	2/93	2/100	T/75
Vaccinium myrtillus	T/100	•	•	38/100	•	•	•	•	•	•	•	•
Vitis erizonica	•	•	•	•	•	•	•	•	•	•	•	•
Yucca engustissima	•	•	•	•	•	•	•	•	•	•	•	•
Yucca beccata	•	•	•	•	•	•	•	•	T/20	•	•	•
Yucca schotti	•	•	•	•	•	•	•	•	•	•	•	•
Graminoids												
Agropyron smithii	•	•	•	•	•	•	•	•	•	•	•	•
Andropogon gerardi	•	•	•	•	•	•	•	•	•	•	•	•
Aristida arizonica	•	•	•	•	•	•	•	•	•	•	•	•
Blepheroneuron tricholepis	•	•	•	•	•	•	•	•	•	T/7	•	•
Bouteloua gracilis	•	•	•	•	•	•	•	•	•	T/7	•	•
Bromus ciliatus	T/50	14/100	T/57	•	1/33	T/100	4/100	T/100	12/40	T/14	45/100	1/100
Carex spp.	T/50	•	•	•	•	T/25	T/67	T/33	T/20	T/21	•	T/50
Carex foenea	•	T/33	T/71	•	16/100	13/75	•	T/33	T/20	T/14	50/100	•
Cerex geophila	•	•	T/14	•	•	•	•	•	•	•	•	•
Cerex rossii	•	T/33	•	•	•	T/50	3/33	•	T/80	T/43	6/100	1/25
Cyperus spp.	•	•	•	•	•	•	•	•	•	•	•	•
Denthonie intermedia	•	•	•	•	•	•	•	•	•	•	•	•
Elymus triticoides	•	•	•	•	•	•	•	•	•	•	•	•
Festuca arizonica	•	•	2/43	•	3/67	T/25	•	•	T/20	T/7	•	•
Festuca thurberi	•	•	2/14	•	3/67	•	•	•	•	•	T/50	14/100
Festuca sororia	•	6/67	T/29	•	•	•	3/33	•	8/40	•	15/50	•
Juncus spp.	•	•	•	•	•	•	•	•	•	•	•	•
Koelerie nitide	•	•	•	•	T/33	T/50	•	•	T/20	T/21	•	T/100
Lycurus phleoides	•	•	•	•	•	•	•	•	•	•	•	•
Muhlenbergia emersleyi	•	•	•	•	•	•	•	•	•	•	•	•
Muhlenbergia longiligula	•	•	•	•	•	•	•	•	•	•	•	•
Muhlenbergia montane	•	•	•	•	T/33	T/25	•	•	•	T/50	•	T/75
Muhlenbergie virescens	•	•	•	•	•	•	•	•	•	•	•	•
Piptocheetium fimbriatum	•	•	•	•	•	•	•	•	•	•	•	•
Poa fendleriena	•	•	•	•	5/67	T/50	2/33	•	T/20	T/86	T/100	2/100
Poe pratensis	•	•	•	•	•	•	•	•	T/20	T/7	•	•
Schizachyrium scoparium	•	•	•	•	•	•	•	•	•	•	•	•
Sitanion hystrix	•	•	•	•	T/33	•	•	•	T/40	T/57	T/50	2/75
Stipa spp.	•	•	•	•	•	•	•	•	•	T/7	•	•
Stipa pringlei	•	•	•	•	•	T/25	•	•	•	•	•	•
Triselum montanum	•	•	T/14	•	•	•	T/33	•	•	•	3/100	•

PSEM/ MUMO HT (N=5)	PSME/ QUGA HT (N=2)	PIPO/QUGA HT: OUGA typic P (N=5)	PIPO/QUGA HT: PIED P (N=12)	PIPO/QUGA HT: SCSC P (N=5)	PIPO/FEAR HT: FEAR typic P (N=15)	PIPO/FEAR HT: BOGR P (N=2)	PIPO/FEAR HT: OUGA P (N=2)	PIPO/ MUVI HT (N=3)	PIPO/ MUVI-FEAR HT (N=1)	PIPO/ MUMO HT (N=11)	PIPO/ BOGR HT (N=4)	PIPO/ Cinders HT (N=4)	PIPO/ Riparian HT (N=1)	PIPO/ Rock-land HT (N=1)
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
2/60	5/100	2/100	1/33	T/20	T/13	•	1/50	•	5/100	1/36	•	•	T/100	•
T/20	•	T/20	T/8	T/40	T/27	•	•	T/67	T/100	T/45	T/25	•	T/100	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	T/42	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	T/25	•	•	•
•	•	•	T/8	•	•	•	•	•	•	•	•	•	•	•
•	•	•	T/8	•	•	•	•	•	•	•	•	9/25	•	•
•	•	•	•	•	•	•	•	•	•	•	•	T/25	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/60	1/100	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	T/20	•	•	•	•	•	•	•	•	•	•	•	•
1/40	51/100	22/100	11/100	9/80	T/47	T/50	14/100	T/33	5/100	2/82	4/75	T/50	7/100	T/100
•	•	•	T/8	•	•	•	•	•	•	•	•	•	•	•
T/40	•	•	T/33	T/20	•	•	•	2/67	•	T/18	•	•	•	•
T/40	2/50	•	T/8	•	T/13	T/50	T/50	•	•	•	T/25	•	•	•
•	•	•	T/17	•	•	•	•	•	•	•	•	•	•	•
T/20	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
1/40	1/50	T/20	T/8	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	T/50	•	•	•	•	•	•	•	•
T/20	T/50	•	T/25	T/20	•	1/50	•	T/33	•	T/27	•	•	•	T/100
•	•	•	T/17	T/20	T/20	T/50	•	•	•	T/9	•	•	•	•
•	•	•	•	•	T/7	•	•	•	•	•	2/25	•	•	•
•	•	•	•	T/40	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	T/25	•	T/100
T/40	•	T/40	T/25	T/40	T/13	T/50	•	•	•	T/36	T/50	•	1/100	T/100
•	•	•	T/58	T/80	T/7	1/100	T/50	1/100	•	T/45	14/100	T/50	•	T/100
T/40	T/50	T/20	T/17	•	T/17	T/50	•	•	T/100	T/9	•	T/50	•	•
T/20	T/50	T/40	T/33	1/60	T/27	•	1/50	T/100	•	T/36	•	•	•	T/100
T/20	•	•	T/25	•	T/7	•	•	•	•	•	•	•	•	•
•	T/50	•	T/17	•	•	T/50	•	•	•	•	•	•	•	•
T/80	•	T/60	T/33	T/40	2/53	•	•	•	1/100	1/64	3/50	T/50	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	1/100	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	T/50	•	T/8	•	13/93	6/100	15/100	•	12/100	•	•	•	6/100	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	1/100	•
T/80	•	T/60	T/67	2/100	1/73	3/100	•	T/67	1/100	1/73	2/100	T/25	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	3/100	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	T/9	•	•	3/100	•
2/100	•	2/100	1/58	8/100	5/93	5/100	12/100	T/33	•	5/100	3/75	11/75	6/100	•
•	•	•	•	•	•	•	•	15/100	4/100	•	•	•	•	1/100
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
1/80	2/100	3/100	4/92	3/100	2/87	6/100	T/100	T/67	1/100	2/91	2/100	4/75	•	T/100
•	•	•	•	•	T/7	•	•	•	•	•	•	•	1/100	•
•	•	•	T/17	4/100	T/7	•	•	1/100	•	T/27	•	2/75	•	T/100
T/80	1/100	3/100	1/92	T/100	2/80	1/100	2/100	T/100	T/100	2/100	3/100	2/100	T/100	•
•	•	•	•	•	•	•	•	•	•	T/18	•	•	•	T/100
•	•	•	•	•	•	•	•	•	•	T/9	•	•	•	•
•	•	T/20	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Species	PIEN/ Moss[2] HT (N=2)	ABLA/ ACGL HT (N=3)	ABLA/ EREX HT (N=7)	ABLA/ VAMY HT (N=1)	PIPU/ CAFO HT (N=3)	PIPU/ COST HT (N=4)	ABCO/ACGL HT: ACGL typic P (N=3)	ABCO/ACGL HT: Riparian P (N=3)	ABCO/ACGL HT: BERE P (N=5)	ABCO/ QUGA HT (N=14)	PSME/ BRCI HT (N=2)	PSME/ FEAR HT (N=4)
Forbs												
Achillea millefolium	•	T/33	T/43	•	2/100	T/75	T/67	•	T/20	•	T/50	T/25
Antennarie parvifolia	•	•	•	•	T/67	T/25	•	•	•	T/21	•	T/25
Aquilegia elegentula	T/50	T/67	T/86	•	•	•	T/33	3/33	T/40	T/7	2/50	•
Aquilegia chrysantha	T/50	•	•	T/100	•	•	•	•	•	•	•	•
Artemisia franserioides	•	•	•	•	T/33	•	•	•	4/60	•	T/50	•
Artemisia frigida	•	T/33	•	•	•	•	•	•	•	•	•	•
Artemisia ludoviciana	•	•	•	•	•	•	•	T/33	T/40	T/36	•	T/50
Behie dissecta	•	•	•	•	•	•	•	•	•	•	•	T/25
Brickellia grandiflore	•	•	•	•	•	•	•	•	•	•	•	•
Campanule rotundifolia	•	T/33	T/43	•	T/67	T/25	T/67	•	T/20	•	2/100	T/75
Chaptalie alsophila	•	•	•	•	•	•	•	•	•	•	•	•
Cirsium spp.	•	•	T/14	•	•	•	•	•	•	•	•	•
Clematis ligusticifolie	•	•	•	•	•	•	•	•	9/40	T/14	•	•
Clematis pseudoalpina	•	•	•	•	•	•	•	1/100	•	•	2/100	•
Cryptentha jemesii	•	•	•	•	•	•	•	•	•	•	•	•
Cystopteris fregilis	•	T/33	•	•	T/33	T/50	T/33	1/33	T/20	T/14	1/50	T/25
Dugaldia hoopesii	•	•	•	•	•	•	•	•	•	•	•	•
Erigeron spp.	•	•	•	•	•	•	•	•	T/20	T/14	•	•
Erigeron eximius	T/100	2/33	T/100	1/100	1/33	•	T/33	•	T/60	•	1/50	T/25
Erigeron flegelleris	•	•	•	•	1/67	T/25	•	•	T/20	T/21	•	T/25
Erigeron speciosus	•	T/33	•	•	•	•	•	•	•	T/7	•	T/25
Erigeron pletyphyllus	•	•	•	•	T/33	•	•	•	•	•	•	•
Eriogonum jemesil	•	•	•	•	•	•	•	•	•	•	•	•
Eriogonum recemosum	•	•	•	•	•	•	•	•	•	T/7	•	•
Fragaria americana	•	•	T/14	•	2/67	T/50	T/67	T/67	3/60	T/50	8/50	T/25
Fragaria ovalis	•	•	T/29	•	T/33	T/25	T/33	•	•	T/7	•	T/25
Galium boreale	•	T/67	T/14	•	•	•	T/33	•	T/40	T/7	T/50	•
Geranium caespitosum	•	•	T/14	•	•	T/50	•	•	•	T/7	T/50	T/50
Geranium richerdsonii	•	•	T/29	•	3/67	T/25	•	•	T/20	T/14	•	•
Gutierrezla spp.	•	•	•	•	•	•	•	•	•	•	•	•
Haplopappus perryi	•	•	•	•	T/33	T/25	•	•	6/40	T/21	T/50	T/25
Helianthella parryl	•	•	•	•	•	•	•	•	•	•	•	•
Hieracium fendleri	•	•	•	•	•	T/50	•	•	•	T/7	•	•
Hymenoxys spp.	•	•	•	•	•	•	•	•	•	•	•	T/25
Iris missouriensis	•	•	T/14	•	T/33	•	•	•	•	•	•	•
Ipomopsis aggregata	•	•	•	•	•	•	•	T/33	T/20	T/29	•	•
Lathyrus anzonicus	T/100	T/100	5/86	T/100	5/100	1/75	T/67	•	T/60	T/36	1/50	2/100
Lathyrus leucanthus	•	•	T/14	•	•	•	•	•	•	•	8/50	•
Ligusticum porteri	•	•	•	•	T/33	T/50	•	•	T/20	•	1/100	•
Lithospermum multiflorum	•	•	•	•	•	T/25	•	•	•	T/14	•	T/75
Lotus wrightil	•	•	•	•	•	•	•	•	•	•	•	•
Lupinus spp.	•	•	T/29	•	T/33	•	•	•	•	•	•	•
Malaxis soulei	•	•	T/29	•	•	•	•	T/67	T/60	T/29	•	•
Mertensie frenciscana	•	T/33	•	•	T/33	T/75	T/67	T/33	T/20	T/14	3/50	T/25
Osmorhiza depaupereta	•	1/100	T/71	•	T/33	T/50	T/100	13/33	4/40	•	8/50	•
Oxalis metcalfei	•	•	•	•	•	•	•	•	•	•	•	•
Penstemon spp.	•	•	•	•	1/67	•	T/33	1/67	T/20	T/36	1/50	•
Penstemon barbatus	•	•	•	•	•	•	•	•	•	T/7	T/50	T/25
Polemonium foliosissimum	•	T/33	•	•	•	•	•	T/67	T/60	T/21	•	•
Pseudocymopteris montenus	T/50	•	T/71	•	3/67	•	T/33	•	T/80	T/14	2/50	T/50
Pseudostellaria jamesiena	•	•	•	•	•	•	•	•	•	•	•	•
Ramischia secunda	T/100	T/67	T/57	T/100	•	•	•	•	•	•	T/50	•
Senecio eremophilus	•	T/33	•	•	•	•	•	T/67	T/60	T/21	•	•
Senecio neomexicanus	•	•	•	•	•	T/25	•	•	T/40	T/29	•	T/50
Senecio sacramentanus	•	•	•	•	•	•	•	•	•	•	•	•
Senecio sanguisorboides	•	•	•	•	•	•	•	•	•	•	•	•
Senecio wootonli	•	•	•	•	•	•	•	•	•	•	T/50	T/25
Sisymbrium spp.	•	•	•	•	•	•	•	•	•	T/7	•	•
Smilecina racemosa	•	•	T/14	•	T/67	T/100	•	1/100	T/40	•	T/50	•
Smilacina stelleta	T/100	•	1/43	•	T/33	1/25	1/33	•	•	T/14	T/50	T/25
Stellaria longifolie	•	3/33	•	•	4/33	T/25	•	•	4/60	T/21	•	•
Thalictrum fendleri	•	T/33	T/14	•	1/100	5/100	T/67	2/100	T/100	T/71	3/50	T/25

PSEM/ MUMO HT (N=5)	PSME/ QUGA HT (N=2)	PIPO/QUGA HT: QUGA typic P (N=5)	PIPO/QUGA HT: PIED P (N=12)	PIPO/QUGA HT: SCSC P (N=5)	PIPO/FEAR HT: FEAR typic P (N=15)	PIPO/FEAR HT: BOGR P (N=2)	PIPO/FEAR HT: QUGA P (N=2)	PIPO/ MUVI HT (N=3)	PIPO/ MUVI-FEAR HT (N=1)	PIPO/ MUMO HT (N=11)	PIPO/ BOGR HT (N=4)	PIPO/ Cinders HT (N=4)	PIPO/ Riparian HT (N=1)	PIPO/ Rock-land HT (N=1)
T/60	T/50	T/60	T/17	T/20	2/47	•	2/100	T/67	•	T/55	•	•	T/100	T/100
T/40	•	T/40	T/33	T/40	T/53	T/50	T/100	•	T/100	T/45	T/25	T/25	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	T/7	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/60	•	T/40	T/42	T/40	•	•	T/50	•	•	T/18	T/50	•	•	•
T/40	•	T/60	T/17	T/40	T/13	•	•	T/33	•	T/36	•	T/75	•	T/100
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/40	T/50	•	•	T/20	T/13	T/50	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	T/20	•	T/40	•	•	2/50	•	•	T/36	•	T/25	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	T/7	T/50	•	•	•	•	•	•	T/75	•	•
•	•	•	T/17	•	•	T/50	•	•	•	T/9	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	T/20	T/17	T/20	•	•	•	•	•	•	T/25	T/25	•	T/100
•	•	•	•	•	T/7	•	•	•	•	•	•	•	•	•
T/20	•	•	T/33	T/40	T/40	T/50	T/100	T/33	•	T/36	T/100	•	T/100	•
T/80	1/50	T/20	T/17	T/20	T/33	T/50	•	•	•	T/45	•	•	•	•
•	•	T/20	•	•	•	•	•	•	•	T/9	•	•	•	•
T/20	•	•	•	T/20	•	T/50	•	T/33	•	•	•	•	•	•
•	•	T/40	T/50	T/40	T/7	T/50	•	•	•	T/18	1/50	•	•	•
T/20	2/50	•	•	•	•	•	•	•	•	•	•	•	•	•
T/20	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/20	T/50	•	T/8	•	•	•	•	•	•	T/9	•	•	T/100	•
T/40	•	•	T/25	•	T/7	•	T/50	T/33	•	T/27	T/25	T/50	T/100	•
T/20	•	•	•	•	T/7	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/20	•	•	T/8	•	•	•	•	•	•	•	•	•	•	•
T/20	•	•	•	•	•	•	•	•	1/100	•	•	•	•	•
T/40	•	•	T/8	T/40	T/27	•	T/50	T/67	T/100	T/36	•	T/25	•	•
T/20	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	T/13	•	6/50	•	•	•	•	•	T/100	•
T/60	•	T/40	T/17	T/40	T/27	•	•	T/33	•	T/45	T/50	T/75	•	•
T/40	2/50	•	T/17	T/20	T/13	•	3/100	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	T/50	•	•	•	•	•	•	•	•	•	•	•	•	•
T/60	•	T/80	T/25	T/60	T/20	•	•	•	T/100	T/27	•	T/75	T/100	•
T/20	•	T/60	T/25	T/40	T/33	•	•	T/100	T/100	T/55	T/25	T/75	•	•
T/20	•	T/20	•	•	T/13	•	•	•	•	T/9	•	T/25	•	•
•	•	T/20	•	•	•	•	•	•	•	•	•	•	•	•
T/40	2/50	T/20	•	•	•	•	•	•	•	T/9	•	•	•	•
•	•	•	T/8	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/20	•	•	T/42	T/40	T/13	•	•	•	•	1/18	T/50	T/25	T/100	T/100
•	T/50	T/20	T/25	•	T/20	•	•	T/33	•	T/18	•	T/50	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/80	•	T/60	•	T/40	T/73	T/50	3/100	T/33	T/100	T/45	•	T/25	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	T/100	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/60	T/50	T/80	T/67	T/80	T/67	T/50	•	T/100	T/100	T/64	T/50	T/50	T/100	T/100
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/20	•	T/20	T/8	•	T/7	•	•	•	•	•	•	•	•	•
T/40	T/50	T/20	T/17	T/80	T/20	•	•	•	•	T/55	T/25	T/50	•	T/100
•	T/50	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
T/60	T/50	T/40	T/42	T/20	T/7	•	•	•	•	T/27	•	T/25	T/100	•

Appendix E. Continued

Species	PIEN/ Moss[2] HT (N=2)	ABLA/ ACGL HT (N=3)	ABLA/ EREX HT (N=7)	ABLA/ VAMY HT (N=1)	PIPU/ CAFO HT (N=3)	PIPU/ COST HT (N=4)	ABCO/ACGL HT: ACGL typic P (N=3)	ABCO/ACGL HT: Riparian P (N=3)	ABCO/ACGL HT: BERE P (N=5)	ABCO/ QUGA HT (N=14)	PSME/ BRCI HT (N=2)	PSME/ FEAR HT (N=4)
Thermopsis pinetorum	•	•	T/14	•	T/33	T/50	•	•	•	T/7	•	•
Veleriane spp.	•	•	•	•	•	•	•	•	•	•	•	•
Veleriene capitata	•	•	•	•	•	•	1/100	T/33	•	T/14	13/50	•
Vicie emericene	•	1/33	3/43	•	6/100	T/100	T/67	•	1/60	T/21	2/50	T/100
Viole canadensis	T/50	T/33	T/29	•	T/67	T/50	T/33	2/33	1/60	•	T/50	T/25

Species	PSEM/ MUMO HT (N=5)	PSME/ QUGA HT (N=2)	PIPO/QUGA HT: QUGA typic P (N=5)	PIPO/QUGA HT: PIED P (N=12)	PIPO/QUGA HT: SCSC P (N=5)	PIPO/FEAR HT: FEAR typic P (N=15)	PIPO/FEAR HT: BOGR P (N=2)	PIPO/FEAR HT: QUGA P (N=2)	PIPO/ MUVI HT (N=3)	PIPO/ MUVI-FEAR HT (N=1)	PIPO/ MUMO HT (N=11)	PIPO/ BOGR HT (N=4)	PIPO/ Cinders HT (N=4)	PIPO/ Riparian HT (N=1)	PIPO/ Rock-land HT (N=1)
	•	•	•	•	T/20	•	•	•	•	•	•	•	•	T/100	•
	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	•	T/50	T/20	T/8	T/20	T/20	•	T/100	•	•	T/9	•	•	•	•
	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

[1]*Occurrence of each species in each habitat type and phase is indicated by two values separated by a slash. The first indicates the mean constency for each species in the habitat type or phase; it is the percentage of the total number of plots in the group in which the species was found. In cases where a species had less than 1% cover, T is used to the left of the slash. A dot indicates that the species was not found in a group.*

[2]*Descriptions of habitat types with small sample size (N = <5) were derived as explained under Results and Discussion section.*

Alexander, Billy G., Jr., E. Lee Fitzhugh, Frank Ronco, Jr., and John A. Ludwig. 1987. A classification of forest habitat types of the northern portion of the Cibola National Forest, New Mexico. USDA Forest Service General Techical Report RM-143, 35 p. Rocky Mountian Forest and Range Experiment Station, Fort Collins, Colo.

Forest habitat types in the Cibola National Forest (except the Magdalena District) of New Mexico were identified and described to develop an ecosystem classification based on potential natural vegetation. The final classification utilized data from 124 sample plots. A total of 6 climax series, 21 habitat types, and 9 phases of habitat types are defined. Keys and descriptions for each habitat type are provided. Vegetational relationships, physical settings, and relationships to adjacent habitat types and other habitat type investigations in the Rocky Mountians are discussed.

Keywords: Forest vegetation, New Mexico, habitat types, plant communities, plant associations, forest ecology, forest management.

Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

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Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

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*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526